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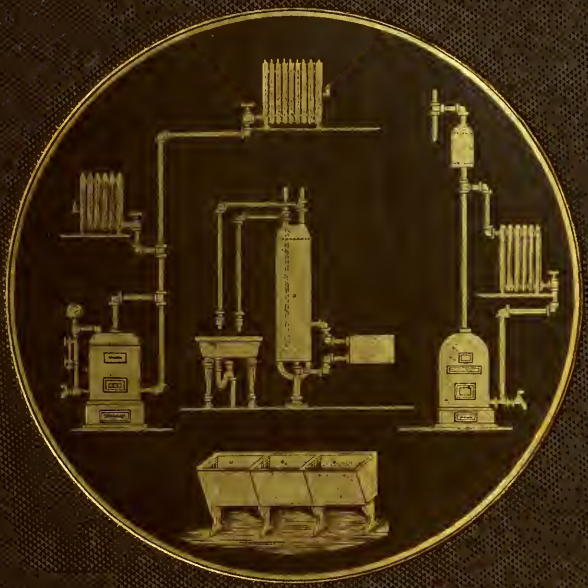

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MODERN PLUMBING,

STEAM AND HOT WATER HEATING

A NEW PRACTICAL WORK FOR THE PLUMBER, THE HEATING ENGINEER, THE ARCHITECT, AND THE BUILDER

BY

JAMES J. LAWLER

AUTHOR OF "AMERICAN SANITARY PLUMBING," "HOT WATER HEATING," "STEAM AND GAS FITTING," "DOMESTIC HYGIENICS," ETC., ETC.

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INTRODUCTION.

After many years of practical contact with mechanics in the construction of steam and hot-water plants and plumbing work, I find that there is no language so clear, so simple, and so easily understood by such persons, as the language of drawings. This is but natural, as a drawing to a mechanic speaks louder than words, it is a tangible proof of what it means.

I propose, therefore, to make practical drawings, sketches, and illustrations, the special feature of this book, with simply brief explanations of the various things considered.

It is quite safe to say that more than one-half the plumbing concerns doing business in the United States of America also carry on the work of constructing steam and hot-water plants.

It may also be said that any building, at the present time, of much importance, having modern plumbing fixtures, will also be found to have either steam or hot-water appliances. In many places it becomes absolutely necessary for the mechanics who carry out the plumbing arrangements of a house or building, to also do the constructing of the steam or hot-water plant for such buildings. The two trades are fast amalgamating in one. The architect must understand both, and the builder is interested in the various trades. It is therefore hoped that a work of this kind will be of great practical value, not only to those engaged in the plumbing, steam, and hot-water business, but to all who are interested in the building trades.

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PLUMBING.

The ancient meaning of plumber is a worker in lead. One who prepares lead pipes and other apparatus for the conveyance of water. The meaning of the word plumbing is the art, or process of casting in lead and using it in building operations.

If the plumber of twenty years ago had fallen asleep and awakened only to-day, he would find himself without a trade. Such great changes have taken place within the last few years, that the plumbing arrangements of a quarter of a century ago, and the plumbing of to-day could bear no comparison. There was a time when the plumber made by hand nearly everything he used of lead. At the present time, most all things used in plumbing work are made of other than lead, and not by hand but by machinery.

These changes that have taken place are great sanitary improvements, and are fully in keeping with the advancements made in other directions. As the trade of the plumber has so completely changed from that of our grandfathers' days, there is no good reason why the name of plumber should not be changed also, and substitute the name sanitary artisan instead.

Sanitary science is the business of the plumber of to-day, and any complete treatise on this subject would require volumes. But an attempt will be made in the first part of this book to furnish practical hints to persons engaged in the construction of plumbing work, which will enable them to carry out correctly and in complete manner the most modern systems of plumbing and house drainage.

Perhaps the most important thing with which the plumber should be armed, is a proper knowledge of soil and waste-pipe ventilation. Other things connected with the plumbing fixtures of a house are secondary and mechanical. To know how to prevent sewer and waste-pipe gases from entering the house through the plumbing fixtures under the varying conditions, will require a high degree of scientific knowledge. The plumber, therefore, must study and get down to bottom principles of the various things connected with this science, if he ever hopes to take a place in the front ranks of his profession.

The conveying of fresh water to and through a house for domestic purposes, is a comparatively simple matter, but the conveying away from the house, or the disposal of the waste and unclean water without bad effects, is quite another thing, and not by any means a simple matter. The reason for this is that, as soon as water is made foul by any matter, it begins to undergo chemical changes as such matter decomposes, and we then have something more than unclean water to convey from the house, and this something more is the products of decomposition, commonly called *sewer gas*.

It is unnecessary in these enlightened days to dwell upon the bad effects of the foul gas when taken into the human lungs, but suffice it to say that thousands of deaths can be traced to no other cause than the inhaling of this deadly poison.

As the matter of house drainage, soil, and waste-pipe ventilation is considered by the author to be the most important part of the plumbing business, it will be considered first, and other branches of the trade afterwards.

Waste Water and Waste-Pipes.

In conveying waste or unclean water from premises, pipes are used as a matter of convenience, and while this is an advantage there comes with it some disadvantages, one of which is the generating of the foul gas from the decomposition of that which contaminated the waste water, and while the waste-pipe is intended for, and is supposed to carry off all that is allowed to flow into it, the waste-pipe falls very much short of accomplishing completely the purpose for which it is intended. To make this point more clear we will suppose that the sketch, Fig. 1, is a short piece of waste-pipe with an enlargement on top and into which waste water is poured and carried away, there being no trap or anything to obstruct the flow of water out of the pipe, not even a strainer on top which might retard its flow, yet all that is poured in at the top of even this simple piece of waste-pipe, does not pass out at the bottom, and this is the fundamental cause of foul odor from house drains, soil, and waste pipes.

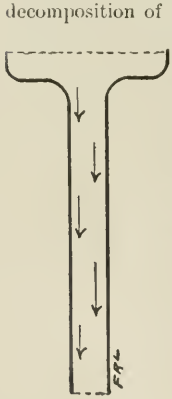


Fig. 1.

If a simple piece of waste-pipe, as shown in Fig. 1, is used constantly for a year or so, receiving foul waste water daily, there would

be a considerable amount during this time of the waste water that had entered the top, which never passed out at the bottom, and while the pipe may appear perfectly clear, the question might be asked, "Where did this go to?" The answer is plain, if this waste water unaccounted for did not pass from the bottom of the pipe, and it is not in the pipe, it must have passed up and out through the top of the pipe, and so it did, not as a liquid but as a Gas.

This therefore is the reason why it becomes necessary to ventilate waste-pipes of any and every description. As such foul gases are not desirable through the atmosphere of the house, and their weight or specific gravity will not permit them to pass down and out as the waste water, it becomes necessary to provide a special outlet for this gas, so that it will be delivered to the outside atmosphere at a point above all windows, where it can do no harm.

If it be necessary to ventilate a waste-pipe whose length is but a foot or two, and open to the atmosphere at the bottom, how much more necessary it must be to ventilate the network of soil and waste-pipes in large houses and public buildings where there are hundreds and thousands of feet of pipe through which is conveyed not only simple waste water, but fetid matter of every description, and these connecting with miles of city sewer.

The Waste-Pipe after the Waste Water has Passed from it.

The laws of gravitation are accountable for air rising in a vertical pipe, without any other means of force, so that a tube located in a building, and open at each end will be found to have a column of air in motion passing in at the bottom and out at the top as indicated by the arrows in Fig. 2.

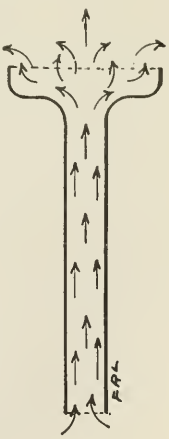


Fig. 2.

Whatever filthy moisture there is left remaining on the sides of the waste-pipe after the water has been discharged will be carried along by the air circulating up the pipe, and thus find its way to the atmosphere of the house.

As waste water cannot be permitted to flow on to the open ground, but must be conveyed away from the premises by what is known as a sewerage system, all waste-pipes must therefore be connected direct with such sewers. At this point another difficulty arises in the shape of air and gases from the main sewer, which readily find their way up

through the waste pipe and into the house. To permit the waste pipe of a house to act as an outlet for the sewerage system, would be to place such house in condition to poison any human occupant thereof.

So that *sewer traps* were invented for the purpose of cutting off the current of sewer gas from entering the house and at the same time allowing the waste water to pass to the sewer.

Figure 3 shows this improvement with a trap in the waste-pipe under the house fixture, which holds water as indicated by the dotted lines in its lower bend. With this condition of things, let us consider for a moment how much of an improvement as a safeguard against sewer gas we have.

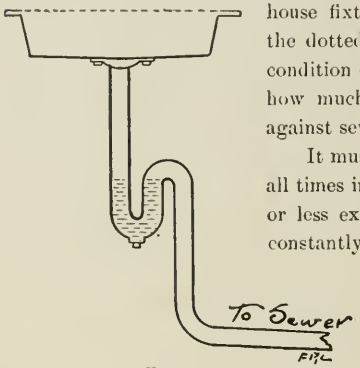


Fig. 3.

It must be remembered that there exists at all times in sewerage systems, a pressure to more or less extent of the air and gases which are constantly pressing against all interior surfaces of such systems and its waste pipe branches, as indicated by the direction of the arrows in the lower part of the waste pipe in illustration Fig. 4. This pressure of air from the main sewer is sometimes strong enough to force down the water on the sewer side of the trap, as shown in Fig. 4 with the water in the trap standing at different levels. So that a trap of this kind having a short dip or shallow water seal of only an inch or so will be found to be insufficient to resist the pressure from the main sewer. Yet allowing that we place traps under fixtures which are sufficiently deep in their construction to withstand any pressure of air from the main sewer, we will still have to contend with gases rising from the decomposition of matter in the waste pipe from the top of the water seal, on the house side of the trap to the fixture, and this will be found to generate from the sides of such parts of the waste-pipes, and pass in the apartments, as indicated by the arrows in

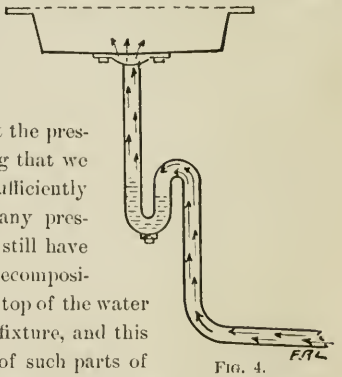


Fig. 4.

the section of waste-pipe above the water seal on the house side of trap in Fig. 4.

A later discovery was the placing of the traps as close as practical to the fixtures as shown in Fig. 5. In order to keep as much as possible of the waste pipes on the sewer side of the trap's water seal. This was another step forward, at the same time it brought with it other complications and among them what is known as *siphonage*. The outlet leg of the trap now being much the longest as shown in Fig. 5, the water falling through this leg, was found to create a suction from the fixture sufficiently strong to pull the water from the trap and thus break the water seal, leaving a free passage for air and sewer gas to pass into the house from the street sewer, as shown in Fig. 6.

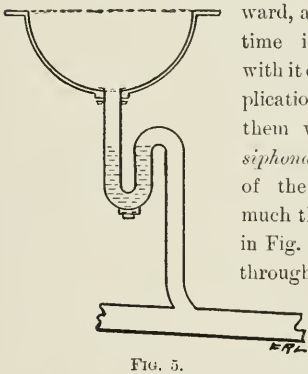


FIG. 5.

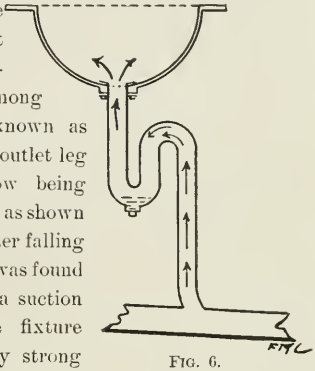


FIG. 6.

SIPHONAGE OF TRAPS AND THE CAUSE.

To properly understand the cause of a siphon, it will be necessary to first understand what is meant by atmospheric pressure. The natural weight of the atmosphere at sea level, exerts a pressure of about fifteen pounds for every square inch of the earth's surface, and as we rise to higher levels this pressure is diminished to a slight extent. For illustration we will suppose Fig. 7 to be a vessel partly filled with water, and having inserted in it a bar of iron A which sinks in the water and rests on the bottom of the vessel, on top of the water, also on top of the bar of iron, are small arrows pointing down, these represent the atmosphere pressing down with its weight of fifteen pounds per square inch. Now, on drawing from

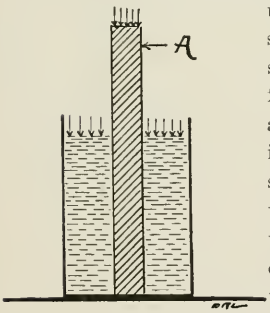


FIG. 7.

the vessel of water the piece of iron A, the water would immediately flow into the space made vacant by the withdrawal of the bar of iron, so that there would be no hole left in the water. This is precisely what happens if we had no water in the vessel, but simply air, as the air would flow in and take the place formerly occupied by the iron.

If we dig a hole in the ground, the space in the earth made vacant is at once filled with air, in the same manner as if we should excavate under water. The water would rush in as fast as the earth is removed, and this is called the law of gravitation.

Fig. 8 represents a bent pipe, or trap with water in the lower sag, as indicated by the dotted lines, and the arrows represent the atmosphere which presses on the water's surface at both sides of the bend. This action of the atmosphere pressing equally on both inlet and outlet end of the pipe, is one reason why the water remains in the dip of the pipe. So that to disturb this water seal, as it may be called, some power other than the atmosphere must be brought into action. We now cause water to flow down the pipe until it fills the lower section as shown in Fig. 9. And as will be noticed by referring to the arrows in Fig. 9, the pressure of the atmosphere has changed its position, and the weight of the water in the lower leg of Fig. 9 from A to B, whatever that distance may be, is the additional power which causes the water to be lifted up from the lower part of the bend in the pipe, and as the water falls away through the lower outlet the air rushes in with its same fifteen pounds pressure and fills the space made vacant.

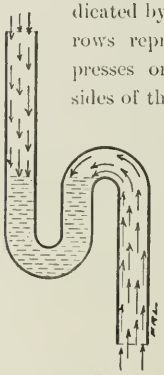


Fig. 8.

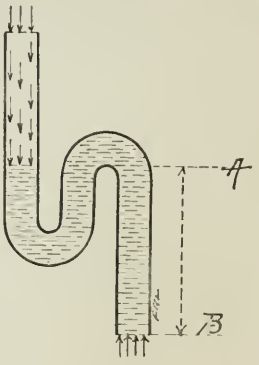


Fig. 9.

Traps Must be Ventilated.

To guard against the siphonage of traps, a remedy was found in ventilating the crown of the trap, by extending an air connection to the outside atmosphere, which would act as a supply channel of air to the lower leg of the trap, when in operation, as indicated in Fig. 10.

This allows the water to flow down the lower leg of the trap, with full capacity without drawing on the water seal, because the pressure of the atmosphere, as may be noticed, is now on both sides of the surface of water which forms the seal, and therefore cannot move unless its surface rises higher on the inlet.

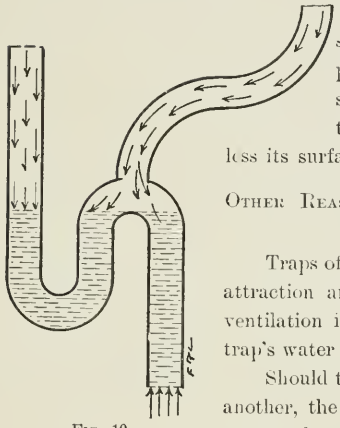


Fig. 10.

Other Reasons why all Traps under Fixtures should be Ventilated.

Traps often lose their water seals by capillary attraction and also by evaporation, so that trap ventilation is in a measure a safeguard after the trap's water seal is broken from any cause.

Should the trap lose its water from one cause or another, the ventilation pipe, if properly placed and connected, would carry air from the fixture as well as from the lower part of trap, as indicated by arrows in illustration, Fig. 11. Except in damp weather, when the atmosphere is heavy, and at such times should there be no water in the *trap*. Air would not only rise from the sewer and pass into the house, but air from the ventilating-pipe would fall down and find its way into such apartments as indicated by the arrows in illustration, Fig. 12.

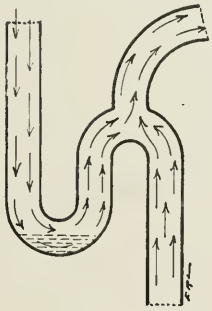


Fig. 11.

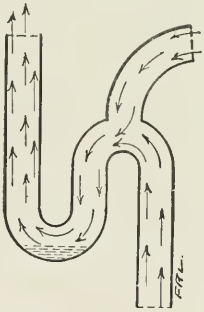


Fig. 12.

The Seal of Traps Broken by Capillary Attraction.

It is not an uncommon thing to find the water of a trap carried off by a piece of towel or rag, as shown in Fig. 13. A small string finding its way through the strainer of a fixture, and hanging over the bend, as shown, lifts the water from the trap, and gradually delivers it over the bend into

the waste-pipe, thus breaking the seal. Traps located in warm places require frequent attention, as the water will quickly evaporate sufficiently to break the seal of the trap. They should therefore receive fresh water at least once a day, to guard against the effects of evaporation. All waste connections should be provided with means of drawing water so as to fill the trap of such fixture with the least possible trouble.

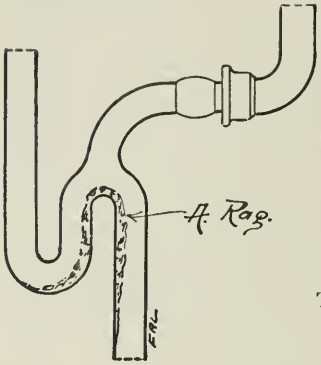


Fig. 13.

The Best and Safest Kind of Trap to Use.

While the markets are flooded with a variety of traps for plumbing fixtures, there is no better construction of this article than that shown in illustrations, Figs. 14, 15, and 16.

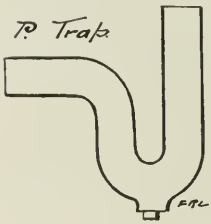


Fig. 14.

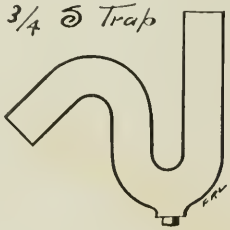


Fig. 15.

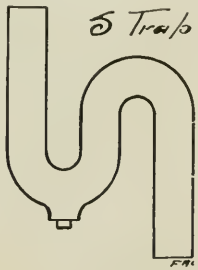


Fig. 16.

This is the ordinary style of trap, and being the same size as the waste-pipe to which it may connect, there is less chance for filth to lodge in it than such as have large bodies.

How Traps Should be Made.

Traps should be formed with graceful curves. Not specially for appearance, but for the purpose of allowing waste water to flow through such bends with as little friction as possible. Hence they should be perfectly smooth on

the inside, as the least roughness on such surface might cause a complete stoppage, by first holding a piece of thread or hair. Traps should never be constructed with interior partitions or tubes, no matter how much water they will hold, for the special reason that the inner tube, or partition, may corrode through at the points marked A, in Figs. 17 and 18, and allow the sewer gas to pass up through the fixture without breaking the water seal, and without showing the defect. Such traps should not be allowed in any house or building.

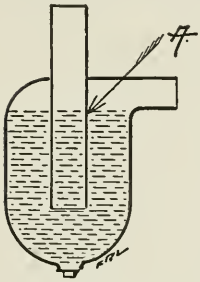


Fig. 17.

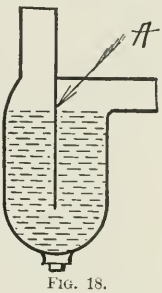


Fig. 18.

Where the bends of traps are separated as those shown in Figs. 14, 15, and 16, there can be no leakage without showing an exterior surface.

Soil and Water Pipe Ventilation.

Having in mind what has been said regarding the generating of gas in soil and waste pipes, the necessity of properly ventilating all such pipes in a house will be seen. All lines of soil and waste pipes are therefore carried, or extended above the highest fixture, and open to the exterior atmosphere at a point above the highest windows of the building. This is for the purpose of allowing all gases to escape which are generated in such system of soil and waste pipes, and also for the purpose of conveying air into such pipes to prevent siphonage from the down flow of waste water.

Street sewers, or cesspools, should not be ventilated *through the soil or waste pipes of a house*. And to guard against the entrance of gases from such sources, a trap is placed on the main line of sewer to the house at some convenient point of access, and this is called the house-trap.

The House-Trap.

Fig. 19 shows the construction of the house-trap, which is provided with two outlets on top, both of which are intended for the purpose of cleaning the same in case of stoppage, and should be provided with brass thimbles, calked into same, and having screw-threaded plugs, so as to be easily removed, and at the same time making perfect water and gas tight joints.

In modern house drainage terra cotta, or clay pipe is not allowed within the walls of any building for use as soil or waste pipe, and it is good practise to extend the iron soil, or waste pipes to a distance from the walls of the building of at least ten feet, before connecting with clay or earthen pipes.

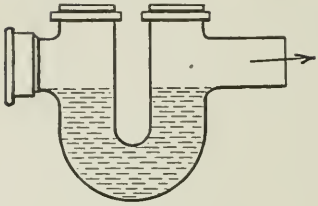


Fig. 19.

Setting the House-Trap.

The drainage should, if possible, be deep enough to drain the cellar floor of a house. And in locating the house-trap this is taken into consideration, after bringing the house sewer line, which is usually terra cotta glazed pipe, within about ten feet from the building. The iron soil-pipe is then connected and carried in through the wall of the house, where the house-trap is the first fitting used, and located as shown in illustration, Fig. 20.

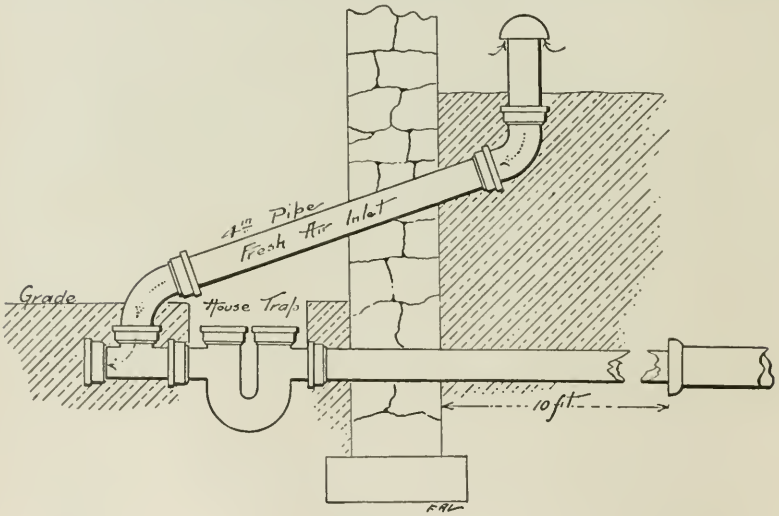


Fig. 20.

The next fitting used on the main line of soil pipe is a tee, with its outlet looking upward and is the connection for the fresh air inlet.

The Fresh Air Inlet.

This is a feature in modern house drainage on which there is much difference of opinion among expert plumbers and sanitary engineers, as to its advantages and utility. Yet the fresh air inlet is accepted as an improvement, and is one of the requirements found in the specifications of house drainage for the most modern structures in the United States at the present time. Referring to the illustration, Fig. 20, it will be noticed that the fresh air inlet extends from a point just inside of the house-trap to a point above the level of the ground on the outside of the house, and its object is to convey fresh air from the exterior atmosphere to the drainage system of the house, for the purpose of carrying off foul gases as they accumulate in the soil and waste pipes, by passing into the main soil pipes at the lowest point in the house and passing out at top of the various vertical lines, which extend again to the exterior atmosphere at points above the highest windows.

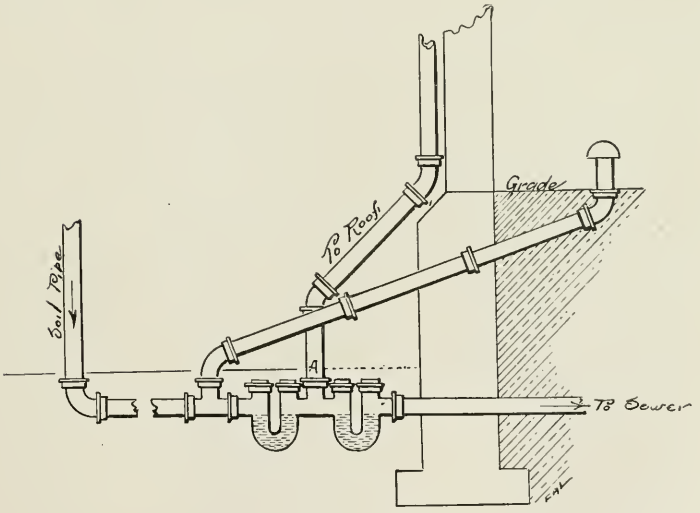


Fig. 21.

The proper size of the fresh air inlet for any ordinary size house system, is considered by the best authorities to be four inches diameter. One of the

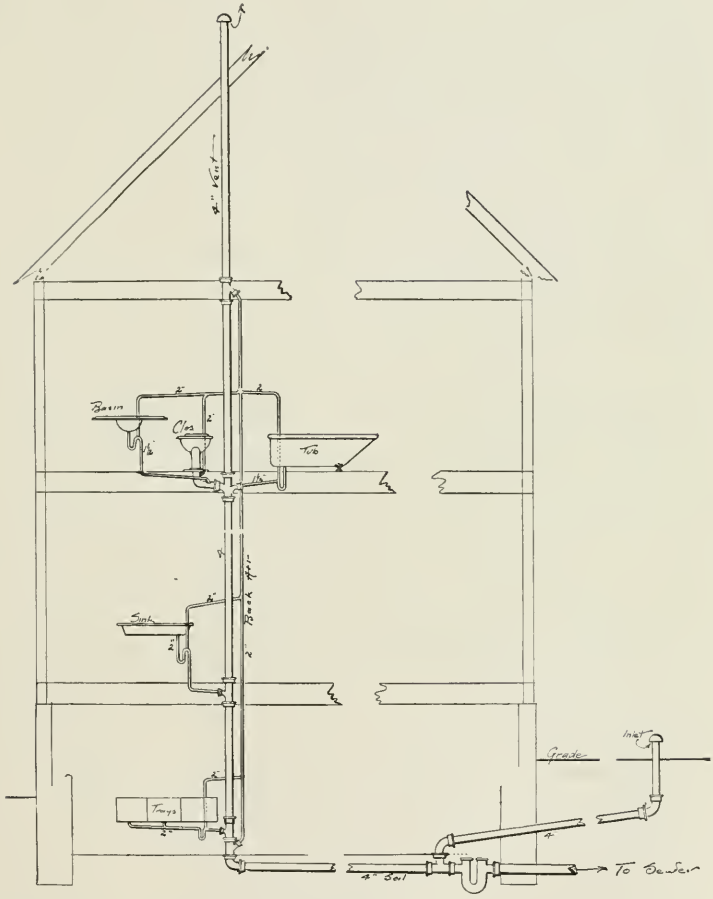
objectionable features with the fresh air inlet, in places where its mouth is located near or under open windows, is the fact that foul odors escape from the inlet at times when the soil pipe is being flushed. The force of water falling down vertical lines drive the air before it, thus forcing the foul odors out through the fresh air inlet.

Double House-Traps.

Illustration, Fig. 21, shows a double house-trap in position. This is claimed by some to be a special protection against the entrance of sewer gas from the street sewer. As will be noticed this trap is provided with a center outlet A, which is intended to ventilate the air space between the two water seals, and at the same time should the pressure of air or gas from the street sewer ever become strong enough to force through the first water seal, it would find escapement through the ventilating branch A, which should extend above the roof of the building without connecting in any manner to any other pipe.

A Complete Plan of Soil and Waste Pipe Drainage.

In the illustration, Fig. 22, we show a complete job of soil and waste-pipe work, as practised by the best sanitary engineers at the present time. This represents such work as may be found in an ordinary private house, with laundry tubs in basement, kitchen sinks on first floor, and water-closet, bath-tub, and wash-basin on second floor. While it is necessary to so locate all fittings and branches so as to get the proper fall and rise to carry out the intention of such systems, the mechanic must also take into consideration the finish and style of this work as to its appearance. And therefore, as may be noticed by referring to the illustration, Fig. 22, branches from and to the main line of soil pipe are taking out between the floors of each story, and lateral branches as far as practical, are carried between the floors. It is desirable here to call attention to the matter of carrying local vent branches from tops of traps, that they should in all cases extend at least a few inches above the top of their respective fixture as shown, for the reason that, should the waste pipe of any fixture become blocked between the soil pipe branch and the fixture, water could not find its way into the soil pipe through the back vent connection, but would overflow the fixtures first.



Plumbing Diagram

FIG. 22.

To Prevent Rust Scale from Choking Back Vent Lines.

Referring to illustration, Fig. 23, it will be noticed that there is some difference in construction from that just described, and the difference consists in the way the lower parts of the back vent lines are connected. Where plain cast iron, or plain wrought iron pipes are used as ventilating lines, it has been

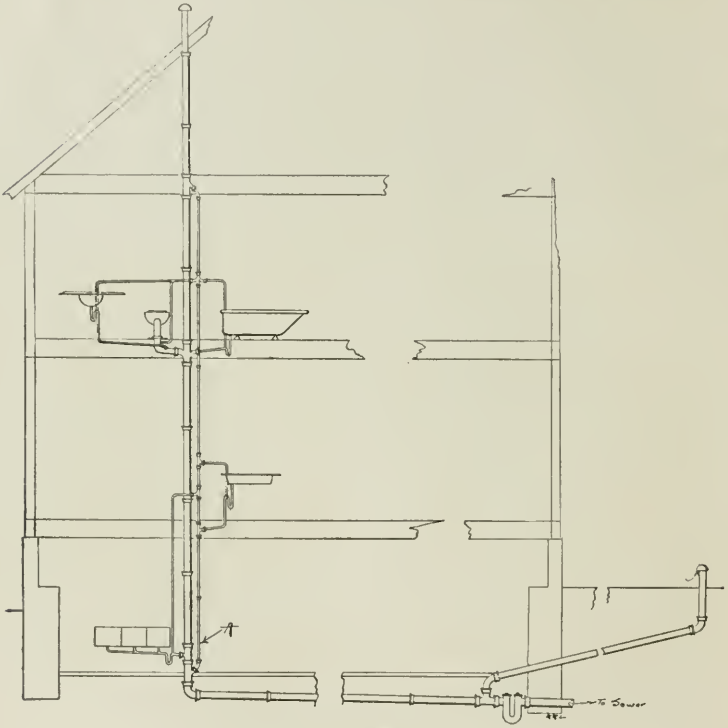


Fig. 23.

found that rust sets in from the dampness and forms scale on the inside, this rust scale falls off at times which drops to the bottom of such connections and blocks the passage, thus rendering the lower connection useless.

To guard against this, a fixture on the first floor which may be a sink or

wash-basin is allowed to drain into the bottom of the back vent line as shown at A in fig. 23. This has the effect of washing away from the bottom of such ventilating lines any rust scales that may fall and thus keep the passage clear. In a system of this kind where there is also fixtures below the first floor, it will be necessary to carry up the back vent line from the crown of the basement, traps to a point above the discharge connection for first floor fixture as shown carried from laundry wash tubs in illustration, Fig. 23.

Cast Iron Soil Pipe and Fittings.

Figs. 24 and 25 show a number of the most generally used soil pipe fittings, and under each fitting is marked the name by which each article is known in the trade. This is an important thing for all engaged in the plumbing business to know, and it is also important to know just where to use these different shaped fittings so as to work them in to the best advantage.

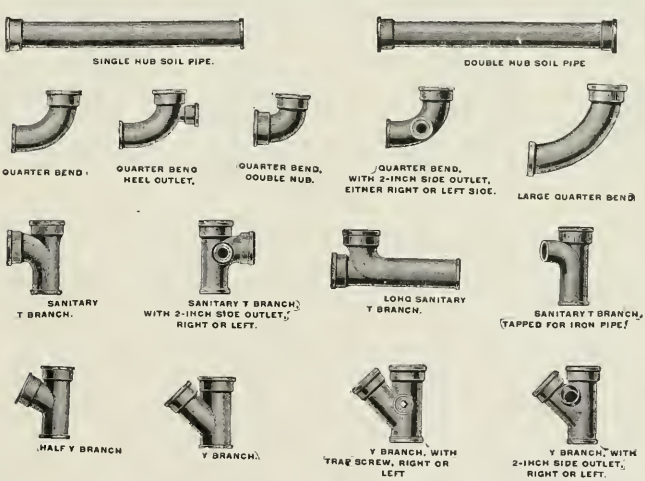

CAST-IRON SOIL PIPE AND FITTINGS.
SINGLE HUB SOIL PIPE.
DOUBLE HUB SOIL PIPE
QUARTER BEND.
QUARTER BEND HEEL OUTLET.
QUARTER BEND, DOUBLE HUB.
QUARTER BEND, WITH 2-INCH SIDE OUTLET, EITHER RIGHT OR LEFT SIDE.
LARGE QUARTER BEND
SANITARY T BRANCH.
SANITARY T BRANCH, WITH 2-INCH SIDE OUTLET, RIGHT OR LEFT.
LONG SANITARY T BRANCH.
SANITARY T BRANCH, TAPPED FOR IRON PIPE.
HALF Y BRANCH
Y BRANCH.
Y BRANCH, WITH TRAP SCREW, RIGHT OR LEFT
Y BRANCH, WITH 2-INCH SIDE OUTLET, RIGHT OR LEFT.

Fig. 24.

If the plumber will carefully lay out his work, with an eye to using the proper fittings in the right place, he will be able to find most any combination of curve or branch in the market, and by so doing produce the best work at the least cost.

Cast-Iron Soil Pipe.

The standard length of cast-iron soil pipe is five feet, the regular style of this pipe is provided with a hub in one end only, and is called single hub pipe. Soil pipe is also made with a hub on each end and is called double hub soil

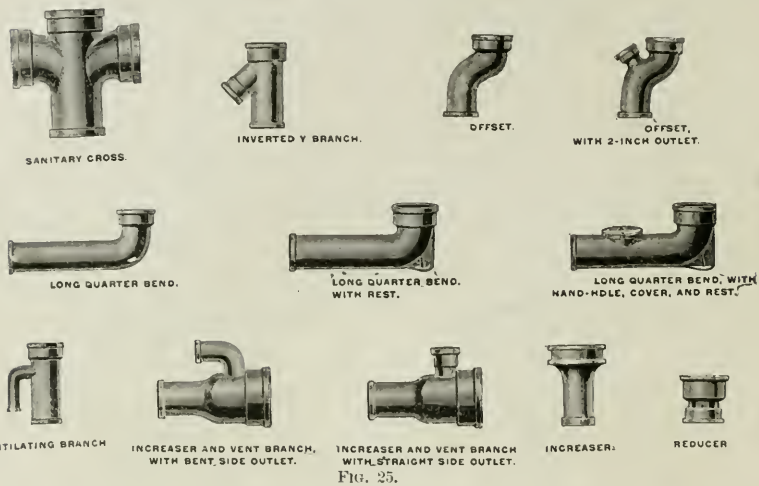


Fig. 25.

pipe. This double hub soil pipe cannot be joined in long runs, but is intended to be cut to finish out ends of lines, and by thus cutting it, two short lengths are made, so that there will be found a slight saving by utilizing the double hub soil pipe in certain places. For example, it often happens that in running lines of soil pipe a piece of six or twelve inches long is required, and to cut this off from a single hub length four feet would be wasted out of the five, for the reason that cast-iron soil pipe without hubs is practically worthless.

Wrought-iron pipe is now largely used in the better class of buildings as soil and waste pipes, so that every joint is a screw-threaded, and therefore cannot work loose by expansion or contraction as in the case where hub joint pipe is calked with lead, this is called *The Wrought-Iron Drainage System*, and for it special fittings are made, some of which are shown in Figs. 26 and 27. In preparing the wrought iron pipes for this class of work, the ends of the pipe are cut off perfectly square so that no bur will be left on the ends.

This is usually done with what is known as a knife cutter, so that it takes out the piece and does not squeeze in the ends of the pipe, leaving on a large bur as in the case of a cut by a wheel cutter. Great care must be exercised in

FIG. 26.

joining these fittings that there be no rough surfaces extending from the ends of the pipe. This wrought-iron drainage system will cost more than double that of the cast-iron soil pipe but is worth the difference.

ROOF CONNECTIONS FOR SOIL AND WASTE PIPE.

As soil and waste pipes must pass through the roof of the building in which they may be placed, it is an important thing to know how to make a storm-proof connection at such point. In Fig. 28 we show a method of making the roof connection which is quite generally used; this illustration explains itself, yet a few remarks on this point will not be out of place. It is a good plan to increase the size of soil pipe at the point of passing through the roof, and especially when back vent lines are connected to the soil pipe in attic as shown, the reason is that should both lines draw air at the same time, which is quite probable, a four-inch pipe passing to the outside

atmosphere would not be large enough to supply the two lines with air. Then again, in cold weather the outlets of soil pipes are often found half choked by frost which accumulates from the moisture in the air passing from

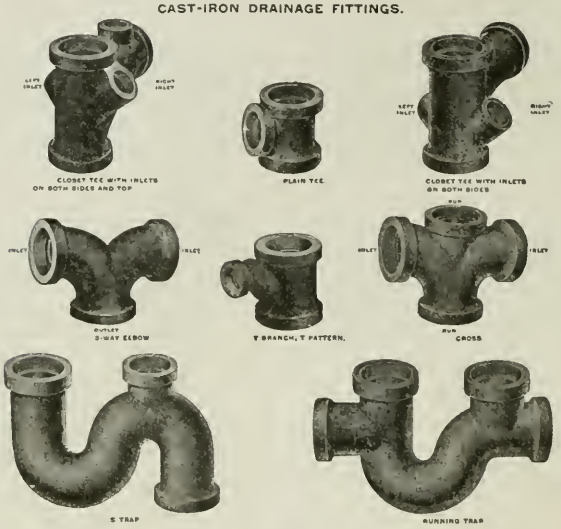


Fig. 27.

the soil pipe. These roof outlets are often found frozen solid, it is therefore important to look after such openings of soil pipe in winter weather and melt away the ice that may have formed thereon.

A Simple Method of Roof Connection.

In Fig. 29 is shown a sewer pipe ventilating cap which makes a storm-proof joint and at much less cost than that shown in Fig. 28. This cap, Fig. 29, is formed in two pieces of cast-iron held together by two bolts, and is applied as shown in illustration 30.

By this method there is a saving in both time and material and it has been used by the writer with the best success in his practical construction work.

How Cap, Fig. 29, is Set and How it Saves Time and Material.

The soil pipe is carried up into the attic from the plumbing fixtures in the usual manner to a point under the roof as shown at C in fig. 30; this may be whatever the full length of soil pipe caused the line to extend, the next thing to do is to cut a hole through the roof which should be just large enough to allow the soil pipe to pass through. A flashing or apron of sheet metal which may be tin, galvanized sheet iron, or copper, is made with a collar or sleeve as shown at A to correspond to the pitch of the roof and the collar extending up ten or twelve inches above the roof, and the diameter of this collar to be large enough to allow the soil pipe to pass through it as shown. The

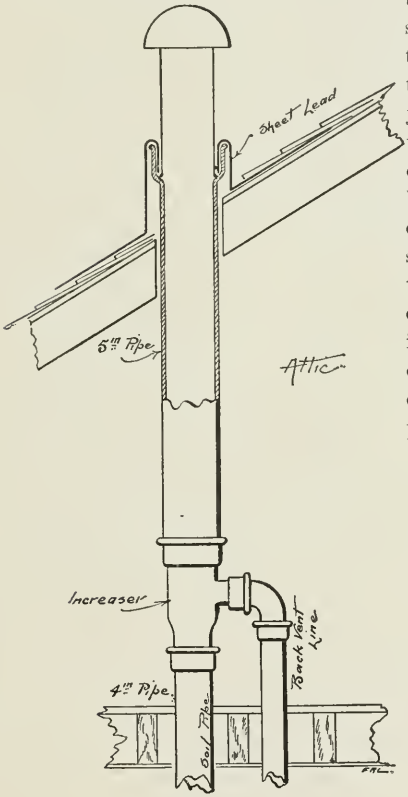


Fig. 28.

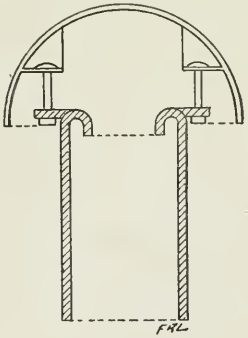


Fig. 29.

next thing to do will be to find a piece of soil pipe without a hub, long enough to extend from the hub of soil pipe at C to the top of collar A. and that will not be hard to find, as there is always large quantities of soil pipe to be found

in a plumbing establishment which are considered waste pieces because they have no hubs, so that this piece is a saving because it would be practically worthless elsewhere.

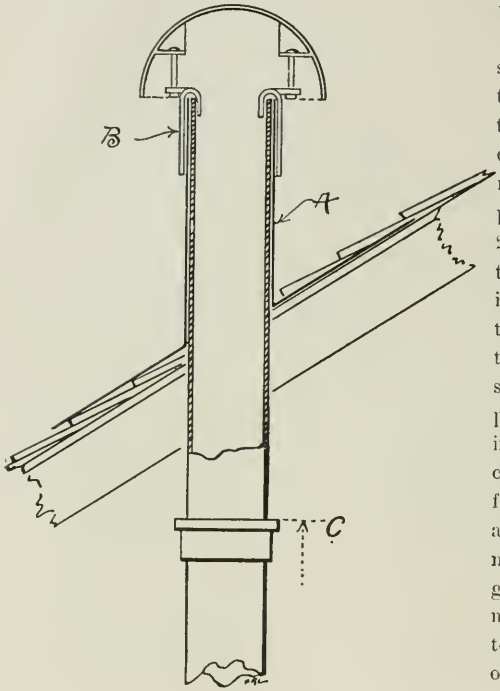


Fig. 30.

This piece of soil pipe is slipped down from above the roof into hub at C, then the joint at C is calked in the usual manner with lead, and made perfectly tight. Cap, Fig. 29, is then placed over the two rough ends extending over the outside of the flashing collar and on the inside of soil pipe as shown, with the result of preventing water entering from the outside, or condensation falling back from the inside of cap, and at the same time making it unnecessary to go on top of the roof with melted lead to calk the top joint as in the case of Fig 28.

Connecting Safe Wastes.

While modern plumbing of the present day is open work, with the fixtures standing on the furnished floors of rooms, there is still many places in which sheet lead safes are used, and I therefore desire to call attention to how such safety pans should be connected, or in other words should not be connected. A safe is a lining of sheet metal, usually sheet lead, placed under plumbing fixtures for the purpose of catching any water that may overflow the fixture, thereby protecting the ceiling below, and for this purpose we use illustration, Fig 31.

In this sketch S represents the lead safe placed on the floor under a water-closet, and which is usually turned up all around the edges to a height of about 3 inches. W. in this sketch, Fig. 31, represents the waste pipe connecting with the safe, and this is simply carried as direct as practical to a point below the cellar ceiling, and at that point provided with a light swinging check valve, or what is called a safe valve, so that there will be no possibility of foul air coming up from the soil pipe or sewer system, as it is in no way connected to the sewerage system. The object of the light swinging valve on the bottom of safe waste-pipe is simply to prevent a current of air from passing through this pipe. The top end of the waste-pipe should be provided with a strainer and this should be raised as safe shown, so that it could not be easily obstructed, and also for the purpose of preventing mice from coming up or passing down this pipe.

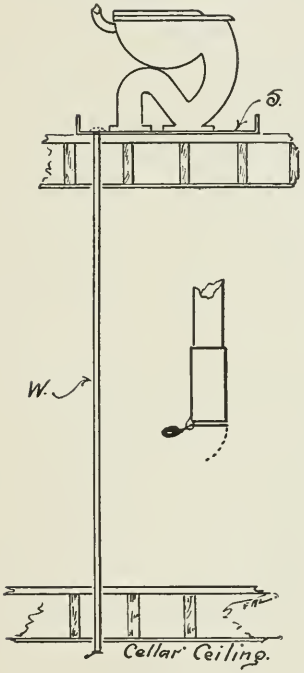


Fig. 31.

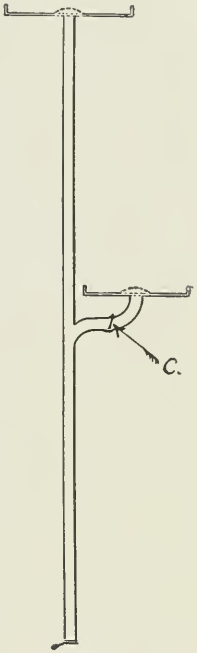


Fig. 32.

In cases where one line of safe waste pipe is used for safes on different floors, it will be necessary to connect as shown in fig. 32 and a separate light swinging check used under all safes except those on the highest floor, for the reason that, should there be no check valve in the pipe at C., air would pass down through the strainer of the lower safe and find its way up and out through the upper safe, and at times this current would change and pass down

from the upper safe and out through those on the lower floor with objectionable results.

Refrigerator or Ice-Box Connections.

Another most important waste-pipe connection to make is that of the ice-box, which should in no case be connected direct to the soil or waste-pipe

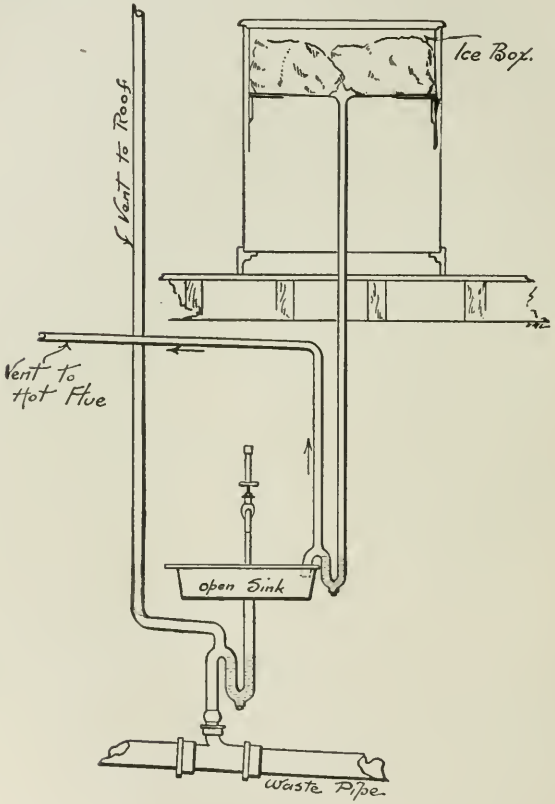


Fig. 33.

system of the house. It will be necessary to dispose of water from the melted ice, and to have a permanent system; the waste-pipe from ice-box should be

connected in some such manner as shown in illustration, fig. 33. This shows a trap at the foot of direct waste-pipe from ice-box, the outlet of which drops into an open sink; the sink is provided with a water supply so as to allow water to fill its trap frequently, the crown of the upper trap is ventilated by a small pipe which should be connected with the kitchen or some other warm smoke flue, while the crown of trap under sink is ventilated in the usual manner, and carried above the roof. Should the water evaporate from the trap under ice-box, with such a ventilating connection as shown, air could not pass up from the sink into the ice-box, but would at all times flow up as indicated by the direction of the arrows and into the heated flue, thus protecting the ice-box against air of any kind finding its way into the ice-box through the waste-pipe.

Calking Cast-Iron Pipe Joints.

To make a reliable calked joint, there is two special things to be considered. First, the proper materials to use and the way in which they are used. The two special materials for this purpose are oakum and molten lead, and these should be of best quality. Plumbers of limited experience have an idea that old scrap lead will answer well enough to calk cast-iron joints, but this is a mistake, for the reason that soft lead which is always the best quality is the safest and best to use; it flows around the hub of the pipe in a proper manner and being soft can be compressed more easily by the calking iron than lead of a harder quality, besides there will be less danger of splitting the pipe by the act of calking. Experience has taught the writer that a good quantity of oakum first packed tightly in the hub of a joint, with a less quantity of lead makes the best job, so that to half fill the hub with oakum as shown in Fig. 34 with the other half lead will be found to give the best results. The oakum must be thoroughly compressed so as to make a solid bed

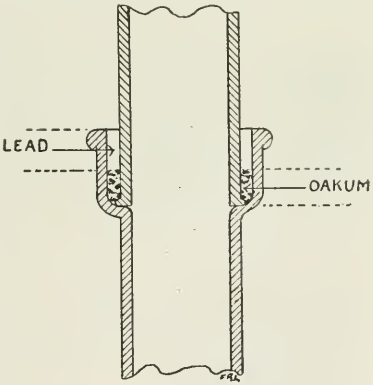


Fig. 34.

for the lead; oakum even without lead can often be made to hold a heavy pressure of water.

Making Lead Connections to Cast-Iron Soil and Waste Pipes.

In connecting lead pipes to cast-iron, there is but one safe method, and that is to wipe the lead to a brass ferrule and calk the ferrule into the hub of the cast-iron pipe with oakum and molten lead, as shown in the illustration, Fig. 35.

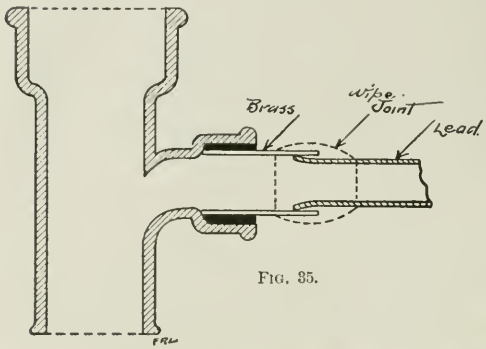


Fig. 35.

Brass Ferrules for this purpose of all necessary shapes, curves, and styles may be found in the market, a few of which are shown in illustration.

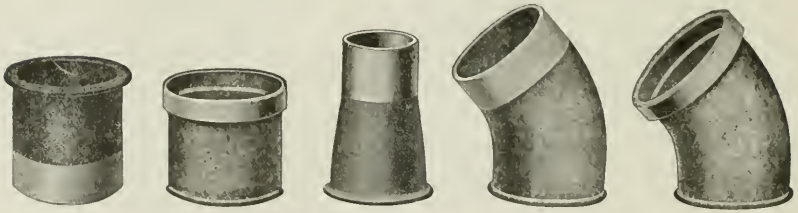


Fig. 36.

Cesspools. How to Build and Locate Them.

To dispose of soil and waste water from houses having modern plumbing fixtures in localities where there are no sewers is a problem that often puzzles the best sanitary engineers. And the difficulty generally comes from the nature of the soil surrounding such premises. A house built upon a rock is not an easy place to locate a cesspool. When the lot on which a house may be located is small, there will also be difficulty. If the ground is composed chiefly of clay soil, it will be bad for the disposal of waste water, and in some

locations, where the earth is of a sandy nature and well adapted for soakage, there will be danger of the sewerage water finding its way into the cellar of the house, or, perhaps worse, into the well or cistern which may be located in close proximity to the cesspool, and therefore the greatest care must be exercised in building and locating the cesspool. Whatever the nature of the ground may be where cesspools are to be located, there is one good plan to follow, and that is to locate and build the cesspool so that it cannot hold water to a point as high as the line of the cellar floor, as shown in illustration, Fig. 37.

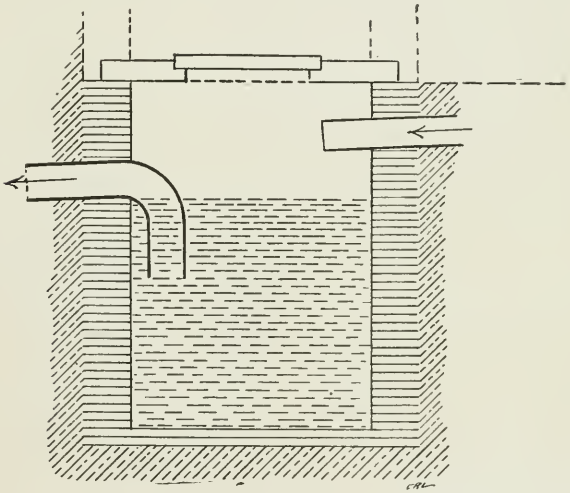


Fig. 37.

To Protect Wells from Cesspool Soakage.

If a well is located on the same lot with that of the cesspool, they should be located on opposite sides of the house as far distant apart as the size of the lot will permit; and at the same time the cesspool should be sunk to a greater depth than the bottom of the well. In ground chiefly composed of clay there will be very little soakage, and therefore a large cesspool should be provided, so as to hold a large amount of water for the reason that it must be pumped out when full. This should be bricked up with good solid masonry and cov-

ered over on top with a strong flag and removable cover made air-tight. In some locations it may be practical to get an overflow connection which may be carried to some point out of danger, so that when full it would be indicated by the water flowing from the outlet, and in such cases the overflow pipe from the cesspool should be connected, as shown in Fig. 37, by a bend with its mouth extending down into the water. By this arrangement the outlet will be trapped against foul smells from the cesspool; and at the same time this bend protects the outlet from becoming choked by paper or other dry substance entering its mouth.

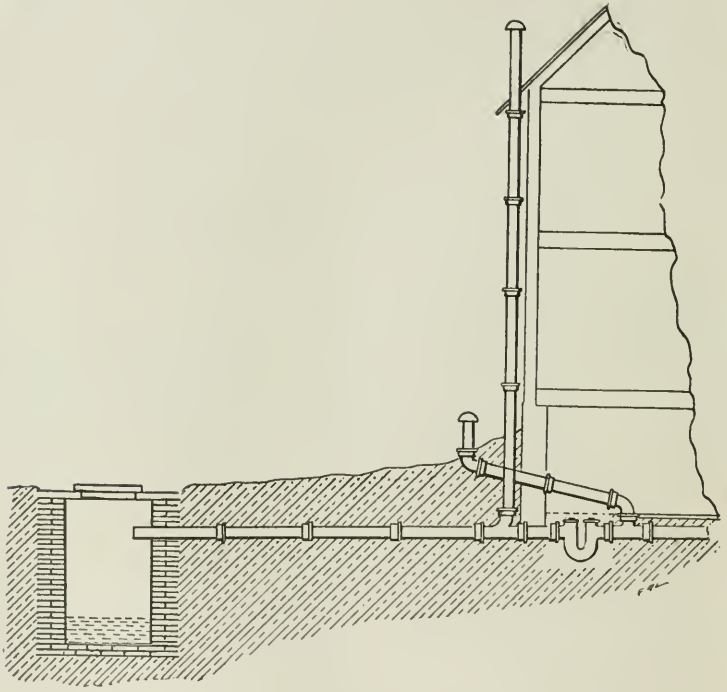


FIG. 38.

HOW CESSPOOLS SHOULD BE VENTILATED.

If cesspools are not ventilated, gas will generate in them in sufficient

quantities to obstruct the flow of water from the house; therefore, a cast or wrought-iron pipe of not less than three inches in diameter is connected with the line of sewer at a point outside of the house-trap and carried above the roof of house, as shown in illustration, Fig. 38.

Grease Traps for Hotels, Institutions, and Large Boarding and Private Houses.

The proper disposal of greasy water is a matter of great importance, for the reason that it is often the cause of great damage and expense by choking the drainage systems. In boarding-houses, hotels, and large institutions there is an enormous amount of waste water allowed to flow into the soil and waste pipes that is heavily charged with grease. Many large private houses also allow large quantities of greasy water to pass into the pipes, which results in choking the same, and often in places very difficult of access. Grease congealed in waste-pipes cannot be forced out by pressure, but must be taken out by opening the pipes and removing the grease by some tool or instrument.

To prevent grease from entering the waste-pipe, special traps are provided under kitchen sinks, or may be located at some other point in which the grease is allowed to congeal before it enters the waste pipe. Provision is also made for its removal, which may be done once a week or so as it accumulates, while at the same time there being no obstruction to the flow of waste water from the sink.

The grease trap is practically a separator dividing the grease from the water as it flows from the fixture.

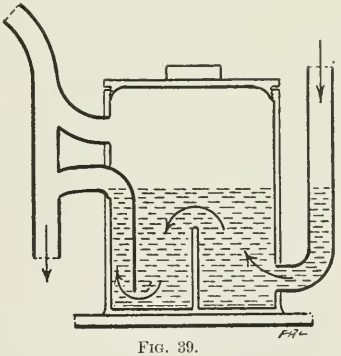


Fig. 39.

The best construction of grease-trap is one in which the waste water is cooled as quickly as it enters the trap, so that particles of grease in the water will cool, and so doing, form into solid matter and rise to the top. In the construction, Fig. 39, it will be noticed, there is a partition running in the center from bottom some distance up, but not to top of water line. This is to prevent, in a measure, the water from passing out of the trap in too direct

a manner, and which will also have a tendency to separate the grease, allowing it to remain on top of the water. The upper part of the body of the trap is provided with a screw-thread cap, so that it can form a perfectly tight joint and at the same time so that it can be easily taken off for the purpose of removing the grease. Such grease-trap must be of good size to be of much value.

Fig. 40 shows a style of grease-trap which answers the purpose very well, and is made in many styles, but the general feature shown here is embodied in them all. This trap is composed of a double cylinder, and cold water is allowed to pass between the two shells as indicated by the dotted lines. This trap is usually placed under the kitchen sink or close to it, and connected in such a manner that all water drawn throughout the house must pass through it. The cold water, therefore, keeps the trap cool at all times; and with such a construction there will be very little chance for grease to find its way to the waste pipe.

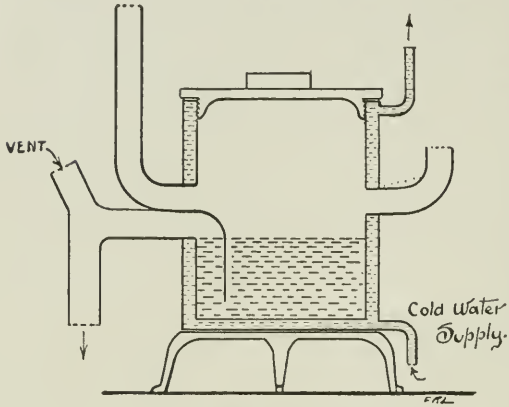


Fig. 40.

Grease Traps Constructed of Brick.

Grease traps are often located in the ground outside the house, and in such constructions care must be exercised to make them perfectly water-tight. They should be built of good sound brick, laid in cement, so that water could could not leak through the walls. The illustration, Fig. 41, gives the general view of how they are made and constructed.

This construction of grease trap will be valuable in places where the house sewer has a long distance to run, as grease allowed to pass into small-sized house branches of good length is a continual source of annoyance in choking the same, often the entire length.

Plumbers' Wiping Metal.

As lead is still used to some extent as branch waste-pipes and water supply pipes, plumbers' metal is also used to connect the same by wiped joints.

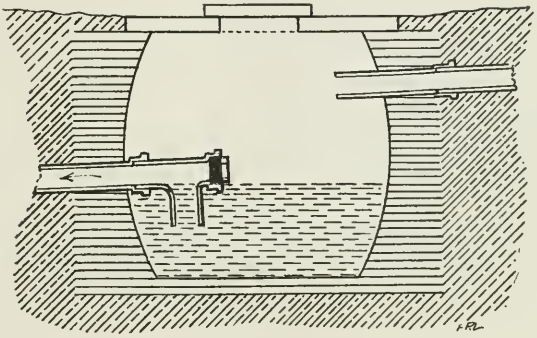


Fig. 41.

It is important to know just how to make good metal for this purpose. Good plumbers' wiping solder is composed of ten parts best quality lead and six parts best quality block tin.

It is easy to spoil wiping metal by impurities of any kind. The slightest particle of zinc dropped into a pot of plumbers' metal will destroy it all for use as wiping solder. Therefore it is not good practise to wipe lead to galvanized iron pipe, and for such cases a brass nipple should be used, screwed to the galvanized iron pipe and the lead wiped to the brass nipple as shown in Fig. 42.

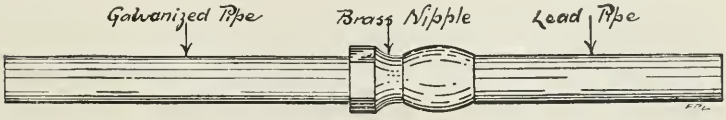


Fig. 42.

How to Make Wipe Joints.

Practise is the only way to know how to make a wipe joint. No person can make a joint of this kind in a proper manner without a considerable

amount of practise. For the reason that it takes time to train the hands and fingers to know by feeling the proper temperature of both the pipe and metal, as well as to be able to manipulate the solder and bring it into a proper thickness and graceful form around the pipe. To have the solder properly unite with the pipe which it is intended to connect, it is necessary to get the pipe up to as high a temperature as that of the melted solder, in order that they may both amalgamate, and this process of heating is usually done by applying the solder until the proper heat on the pipe is attained, and just at that instant is the best time to finish up the joint. It will not do to have the pipe at a higher temperature than the melted solder; for the reason in such a case the solder would run and fall from the pipe, making it impossible to wipe a perfect joint.

It will not do to have the solder too cold at the time of finishing the joint. For the reason that the solder in such a state would finish too coarse, and the result would be that such a joint would sweat and make a poor job.

In wiping lead to brass nipples or another kind of metal an important thing is to properly tin the nipple before it is set in place to be wiped to the lead pipe. It is also the most important in preparing for wipe joints to clean the inner part of pipes to be joined as far as they slip together, so that the metal will flow in between the ends of the pipe as shown in Fig. 43, indicated by the arrows.

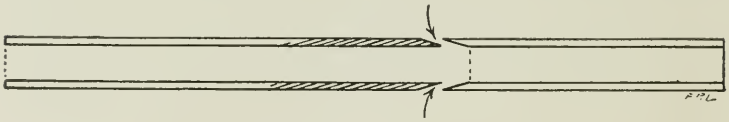


FIG. 43.

In joining lead pipes that are to be wiped together there are two other important things that must be taken into consideration: First, the thickest part of the wipe joint should be on a line with the end of the female part of

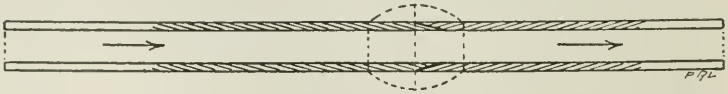


FIG. 44.

the slip joint, as indicated by the center dotted line in illustration, Fig. 44; and, secondly, lead pipe joints should be slipped together in the direction in

which the water moves through the pipe as indicated by the direction of the arrows in illustration, Fig. 44.

This latter precaution is especially necessary in connecting waste pipes so that there will be no rough ends of the pipe to cause obstructions.

Plumbers' Soil and How to Make It.

In making wipe joints on lead pipe it is necessary to protect the parts of the pipe close to the joint, so that solder will not adhere to any part other than that cleaned for the joint, and for this purpose a preparation composed chiefly of lamp black and glue called soil is applied with a brush as indicated by the dark shaded parts of the pipe in illustration, Fig. 45.

Fig. 45.

In making plumbers' soil take one package of lamp black and boil it in water until it dissolves with the water. For this amount of lamp black put in two tablespoonfuls of melted glue. After this has been all dissolved and mixed to a consistency of thin batter, put into the mixture one tablespoonful of powdered chalk and mix thoroughly again.

Soil should be heated each time it is used in order to melt the glue in it, otherwise it will not adhere to the pipe when touched by the wiping cloth.

Melting Point of Alloys.

Lead..	2	Tin..	3	Bismuth....	5	.....	.....	212°
" ..	1	" ..	4	"	5	.....	.....	240°
		" ..	1	"	1	.....	.....	286°
		" ..	2	"	1	.....	.....	336°
" ..	2	" ..	3			.....	.....	334°
		" ..	8	"	1	.....	.....	392°
" ..	2	" ..	1	(solder)		.....	.....	475°
" ..	1	" ..	2	(soft solder)		.....	.....	360°
Zinc ..	1	" ..	1			.....	.....	399°
Lead..	1	Tin..	1	Bismuth....	4	Cadmium		155°

Fusing Points of Metals.

Antimony melts at		810°	Fahr.
Bismuth	" "	500°	"
Copper	" "	2,000°	"
Iron	" "	2,912°	"
Lead	" "	612°	"
Zinc	" "	773°	"
Tin	" "	428°	"

Hydraulics of Plumbing.

The particles of water move over each other without friction, and on this account produces an equal pressure in all directions at the same level.

It is important for the plumber to understand the principles of hydraulics and hydrostatics, because he is in constant contact with these branches of mechanics.

Water is composed by a chemical union of oxygen and hydrogen, in the proportion of—

By weight, oxygen	88.9	parts
" " hydrogen	11.1	parts
" volume, oxygen	1	part
" " hydrogen	2	parts

Expansion of Water.

Water when heated from 40° to 212° expands .046 times its volume, or .00027 of its bulk for each degree.

Water freezes when its temperature falls below 38°, and the boiling point of water is 212° when open to the atmosphere.

Pressure of Water.

The gravity pressure of water is due entirely to the height from which it is taken through pipes. Volume or quantity has nothing whatever to do with the pressure of water. Water, like any other liquid, has its own specific weight, but its pressure due to its height is quite another thing.

A United States standard gallon of water at 39.1° Fahr., barometer at 30 mercury, weighs 8.34 pounds, and is equal to 231 cubic inches. As liquids transmit pressure equally in all directions, this pressure will act sideways as well as downward, and the pressure at any point upon the side of a vessel con-

taining a liquid will be in proportion to the perpendicular depth of the point below the surface.

Illustration, Fig. 46, represents two vessels of water with orifices at the side at different distances from the surface. The water will flow out with a force proportionate to the pressure of the water at these several points, and this pressure is proportionate to the depth below the surface.

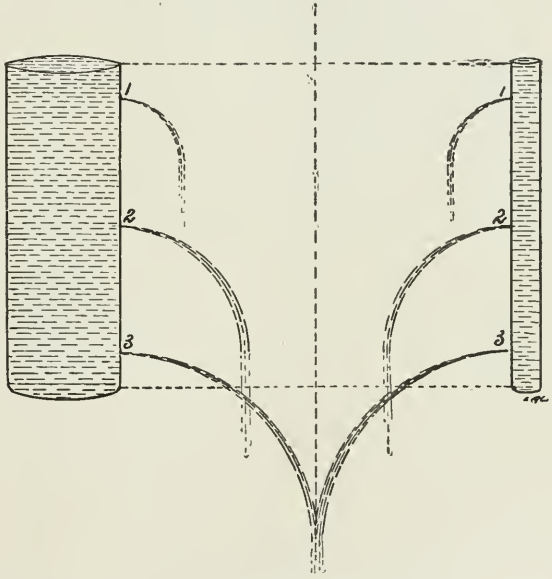


FIG. 46.

For illustration, we will suppose Fig. 46 represents two cylinders of the same height, but one having ten or a thousand times the capacity of the other; it will be found that the streams of water coming from each cylinder will be forced to the same distance, providing the openings are the same size and shape.

PRESSURE OF WATER COMPARED WITH ITS WEIGHT.

The actual pressure produced upon the bottom and sides of a vessel which contains a liquid is always greater than the weight of the liquid. In a cubical vessel, for example, the pressure upon the bottom will be equal to the

weight of the liquid, and the pressure on each of the four sides will be equal to one-half the weight of the liquid; consequently the whole pressure on the bottom and sides will be equal to three times the weight of the liquid, or about 187 pounds pressure.

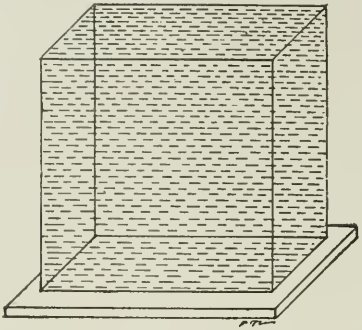


FIG. 47.

TABLE SHOWING THE PRESSURE OF WATER AT DIFFERENT ELEVATIONS.

Feet Head.	Equals Pressure per Square Inch.	Feet Head.	Equals Pressure per Square Inch.	Feet Head.	Equals Pressure per Square Inch.	Feet Head.	Equals Pressure per Square Inch.
1	0.34	100	43.31	195	84.47	290	125.62
5	2.16	105	45.48	200	86.63	295	127.78
10	4.33	110	47.64	205	88.80	300	129.97
15	6.49	115	49.81	210	90.96	310	134.28
20	8.66	120	51.98	215	93.14	320	138.62
25	10.82	125	54.15	220	95.30	330	142.95
30	12.99	130	56.31	225	97.49	340	147.28
35	15.16	135	58.48	230	99.63	350	151.61
40	17.32	140	60.64	235	101.79	360	155.94
45	19.49	145	62.81	240	103.96	370	160.27
50	21.65	150	64.97	245	106.13	380	164.61
55	23.82	155	67.14	250	108.29	390	168.94
60	25.99	160	69.31	255	110.46	400	173.27
65	28.15	165	71.47	260	112.62	500	216.58
70	30.32	170	73.64	265	114.79	600	259.90
75	32.48	175	75.80	270	116.96	700	303.22
80	34.65	180	77.97	275	119.12	800	346.54
85	36.82	185	80.14	280	121.29	900	389.86
90	38.98	190	82.30	285	123.45	1000	433.18
95	41.15						

To further show the great difference there is between the specific weight of water and the pressure of water due to its height, we will make use of the

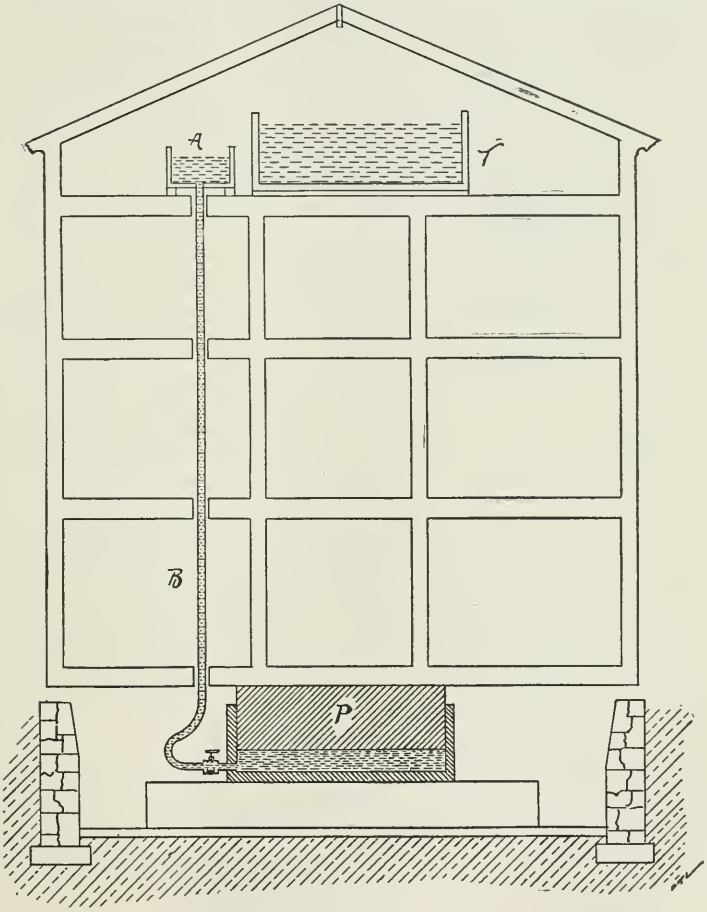


FIG. 48.

experiment shown in illustration, Fig. 48. T in this illustration represents a large house tank filled with water and containing several hundred gallons,

while A is a small tank holding one gallon of water. P represents a plunger or piston, and resting on P is the entire house, including both tanks of water. A small pipe, B, is connected at top with tank A, and at its lower end communicates with a cylinder in which the plunger P. is placed; by having the area of plunger P the necessary size the pressure of water from the small one-gallon tank A. will be sufficient not only to lift up the entire building with the large tank of water, but will also lift up the water in pipe B and tank A less the amount which passes in under the plunger P.

This would look a little like lifting one's self up by his boot-straps, yet it is nevertheless a fact.

Hydrostatic Pressure.

The meaning of hydrostatic pressure is the pressure which water receives from its head or highest level; for example, such as that shown in Figs. 46 and 48.

Hydraulic Pressure.

Hydraulic pressure means the pressure which water receives from mechanical means, such as force pumps.

Water Finds its Level.

Water will rise to the height of its source, after passing through miles of pipes, by simply its own pressure, provided it is properly conducted.

Returning to illustration Fig. 49, let A be a supply from a spring of water falling into a tube, and B is the outlet one mile distant from each other, while the depth of the pipe between them may be one thousand feet below the surface of the supply, the level of water standing in both inlet and outlet will be the same, as indicated in illustration Fig. 49.

The Suction Pump.

A knowledge of the atmospheric pressure, is necessary in order to understand the scope and utility of the suction pump, and without such a knowledge, no mechanic can be of much use in the erecting of such machines.

The atmospheric pressure at sea level is practically speaking 15 pounds per square inch. A column of water 34 feet high will give a pressure at its base of 15 pounds per square inch. It will therefore be seen that the atmospheric pressure will lift or force water to a height of 34 feet in a perfect vacuum.

This height, 34 feet, is therefore the extreme limit of the suction pump, even though such machines could be perfectly constructed.

But such is not the case, and practise has proven that 25 feet is as great a height as will be found practical to lift water by the average construction of suction pump.

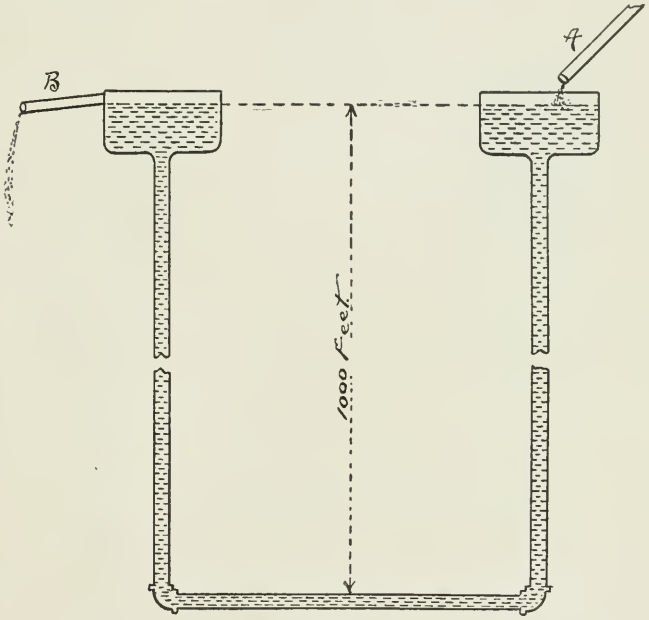


FIG. 49.

A suction pump is composed of four things, namely, a cylinder, a piston and tug valves.

The locating of these two valves in the pump is immaterial, other than one must be above the plunger or piston, and the other below it.

ACTION OF THE SUCTION PUMP.

When the piston of a pump is located above the level of the water it is to elevate, such may be called a suction pump, and when the piston and

cylinder are submerged in the water to be elevated it may be called a simple lift pump. For the purpose of showing the practical operation of this machine we refer to Fig. 50, this shows a cylinder and plunger of a pump with a suction pipe, and the lower end of pipe resting in water. We will suppose the pump to be in action and the plunger moving upwards. This action of

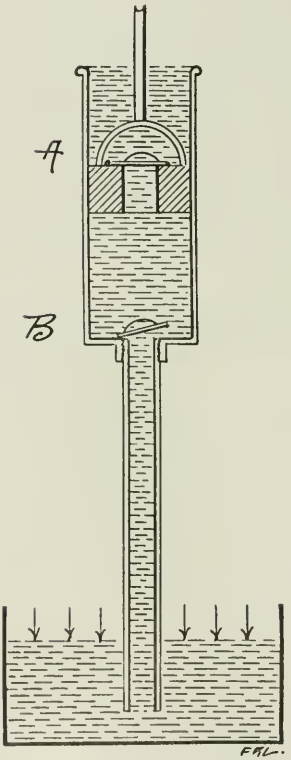


FIG. 50.

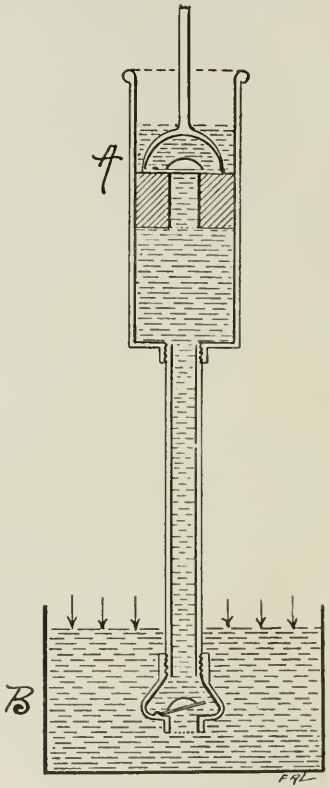


FIG. 51.

the plunger lifts whatever water that may be at the time above the plunger, but it does not lift the water which flows into the lower part of the pump, and as the piston moves up, water also moves in the same direction below the

piston. Therefore, it will be seen that some other power from that applied to the piston forces the water into the lower part of the cylinder, and this is the atmospheric pressure, which is constantly pressing on the surface of the water as indicated by the arrows in Fig. 50 with a pressure of about 15 pounds per square inch.

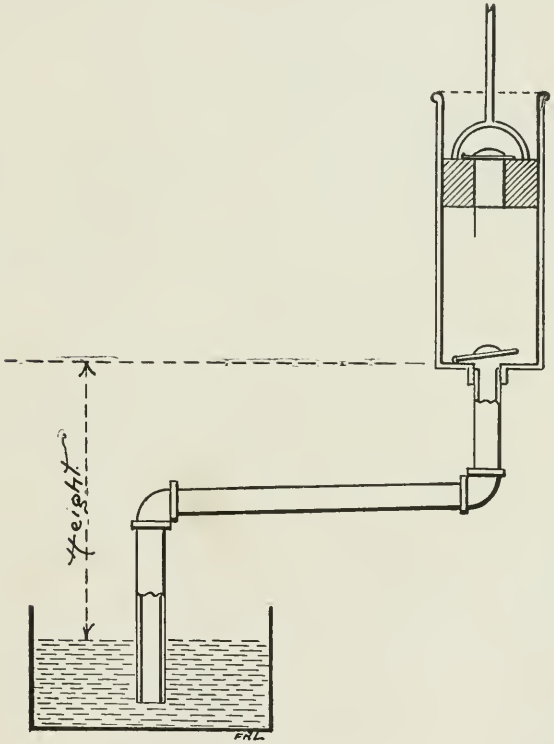


FIG. 52.

As previously stated the greatest height to which water can be lifted by the arrangement of pump as shown in Fig. 50 is 33½ feet, but this can only be done with a perfectly fitted piston. It will therefore be seen that the more perfect the fit of the piston is the greater will be the height to which the

water will be lifted. It is also the greatest importance to have the valves of the pump to fit in as perfect a manner as possible.

It is a good plan when suction pumps are located where they are not liable to freeze to place the lower valve of pump at the lower end of suction pipe as shown marked B in Fig. 51. This keeps the pump primed at all times providing the foot valve at bottom which it is sometimes called, is perfectly tight.

Distance a Pump Will Draw Water.

The horizontal distance, or length of the suction pipe to a pump, does not prevent the water rising to its proper height, but long suction pipes add friction to the flow of water as it rises, and necessitates greater power applied to move the piston, or the suction pipe may be of larger diameter to make up for friction due to its length. The vertical height as indicated in Fig. 52 is alone taken into consideration as to the height water will rise from the surface of water to be lifted to bottom of piston in pump; and this is the same as ascribed for the lift in Figs. 50 and 51.

The Lift and Force Pump.

The lift and force pump is shown in Fig. 53, and is the same pump just described, with the exception of having its top closed and the piston-plunger fitted with a stuffing-box and the water discharged into a pipe having the third check-valve, as shown at A in Fig. 53.

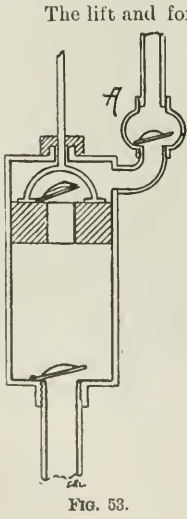


Fig. 53.

There are various modifications of pumps, but they are all based on the principles shown in Figs. 50, 51, 52, and 53.

1 gallon = 231 cubic inches, and contains $8\frac{1}{3}$ pounds water.

$7\frac{48}{100}$ gallons = 1 cubic foot, 1728 cu. in., and weighs $62\frac{1}{2}$ pounds.

1 bushel = $9\frac{3}{10}$ gallons.

$27\frac{7}{10}$ cu. in. of water = 1 pound.

1 cu. in. of water weighs 252 $\frac{69}{100}$ grains.

1 lb. = 7000 grains troy.

1 cu. ft. of water weighs 62.38 lb.

1 cu. ft. of ice weighs 57.25 lb.

WATER EXPANDS .1 of its bulk in freezing.

A COLUMN OF WATER 2.3 ft. high equals 1 lb. per sq. in. pressure.

ORDINARY ATMOSPHERE WILL SUSTAIN 33.9 FT. OF WATER IN HEIGHT.

35.84 cu. ft. of water = 1 ton.

39.84 cu. ft. of ice = 1 ton.

1 cu. ft. of sea water—64.3 lb.

SEA WATER CONTAINS 4 TO 5 OZ. OF SALT PER GALLON.

WEIGHTS OF DIFFERENT METALS.

Lead,	1	foot	square,	inch	thick	= 59.06
Copper,	1	"	"	"	"	= 45.3
Wrought-iron,	1	"	"	"	"	= 40.5
Cast-iron,	1	"	"	"	"	= 37.54
Cast-steel,	1	"	"	"	"	= 40.83

CRUSHING STRENGTH.

Cast-iron,	one	square	inch	= 130.	lbs.
Wrought-iron,	"	"	"	= 84.	"
Lead,	"	"	"	= 7.73	"
Cast Copper,	"	"	"	= 117.	"
Maple Wood,	"	"	"	= 8.17	"
White Pine,	"	"	"	= 5.8	"
Walnut,	"	"	"	= 6.645	"
White Oak,	"	"	"	= 6.1	"
Brick Masonry,	"	"	"	= .6	"

METAL THAT EXPANDS IN COOLING.

Lead, 75, Antimony, 16.7, and Bismuth, 18.3.

EXPANSION OF SOLIDS FROM 32° to 212°, at 32° being equal to 1.

Brass	1.00191
Common Brick	1.00055
Cast Iron	1.00111
Cement	1.00144
Copper	1.00175
Fire Brick	1.0175
Glass	1.00085
Granite	1.00079

Lead	1.00284
Marble	1.0011
Sandstone	1.00174
Steel	1.00119
Tin	1.002
Wrought Iron	1.00126

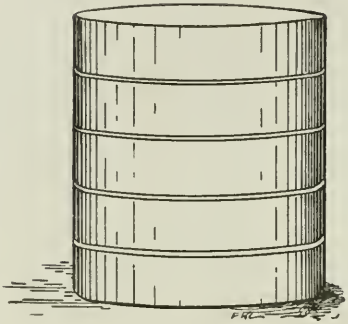


FIG. 54.

NUMBER OF GALLONS IN CISTERNS AND TANKS.

Depth in Feet.	DIAMETER IN FEET.															
	5	6	7	8	9	10	11	12	13	14	15	16	18	20	22	24	25
5	725	1060	1440	1875	2380	2925	3550	4237	4860	5765	6638	7520	9516	11750	14215	16918	18358
6	870	1270	1728	2250	2855	3510	4260	5084	5832	6918	8038	9024	11419	14100	17059	20302	22030
7	1015	1480	2016	2625	3330	4095	4970	5931	6844	8071	9378	10528	13322	16450	19902	23686	25701
8	1160	1690	2304	3000	3805	4680	5680	6778	7836	9224	10718	12032	15225	18800	22745	27070	29372
9	1305	1900	2592	3375	4280	5265	6390	7625	8828	10377	12058	13536	17128	21150	25588	30454	33043
10	1450	2110	2880	3750	4755	5850	7100	8472	9820	11530	13398	15040	19031	23500	28431	33838	36714
11	1595	2320	3168	4125	5230	6435	7810	9319	10813	12683	14738	16544	20934	25850	31274	37222	40385
12	1740	2530	3456	4500	5705	7025	8520	10166	11804	13836	16078	18048	22837	28200	34117	40606	44056
13	1885	2740	3744	4875	6180	7605	9230	11013	12796	14989	17418	19552	24740	30550	36960	43990	47727
14	2030	2950	4032	5250	6655	8190	9940	11860	13888	16142	18758	21056	26643	32900	39803	47374	51398
15	2175	3160	4320	5625	7130	8775	10650	12707	14880	17295	20098	22560	28546	35250	42646	50758	55069
16	2320	3370	4608	6000	7605	9360	11360	13554	15872	1844	21438	24064	30449	37600	45489	54142	58740
17	2465	3580	4896	6375	8080	9945	12070	14401	16864	19601	22778	25568	32352	39950	48332	57526	62411
18	2610	3790	5184	6750	8555	10530	12780	15248	17856	20754	24118	27072	34255	42300	51175	60910	66082
19	2755	4000	5472	7125	9030	11115	13490	16095	18848	21907	25458	28576	36158	44650	54018	64294	69753
20	2900	4210	5760	7500	9490	11700	14200	16942	19840	23060	26798	30080	38062	47000	56861	67678	73424

THE HYDRAULIC RAM.

The hydraulic ram is a machine used for the purpose of forcing water to higher levels than the source of its supply. It is automatic in its action, and its motive power is water taken from running streams. By the aid of the

hydraulic ram it is possible to elevate water to great heights derived from the power of water falling only a few feet.

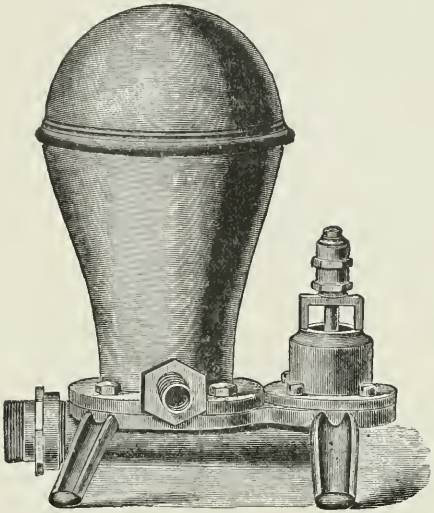


Fig. 55.

Operation of the Hydraulic Ram.

Fig. 56 shows the ram in action. It practically consists of two valves and an air-chamber. In setting the ram it must always be located so that the valve A in Fig. 56 will be situated at a lower level than the source of water supply, as indicated by S. Another important point in setting this machine is to have a sufficient distance or length in the pipe leading to the ram from the spring or source of supply, and this must be at least 25 feet. From 25 to 50 feet will answer all purposes in this, which is called the drive-pipe, indicated by C.

This Action is as Follows:

Valve A closes up against the outlet or with the pressure, and when at rest will be open, as shown by its own weight; valve B is a simple check-valve, and is closed when at rest by its weight. Considerable momentum, or

velocity, in the water running through the drive-pipe is necessary for the successful operation of the machine.

When water starts to run from the spring it finds an outlet in valve A, which is open at the time, and after an instant or two the velocity of the water becomes so strong that it carries with it valve A, lifting it up to its seat,

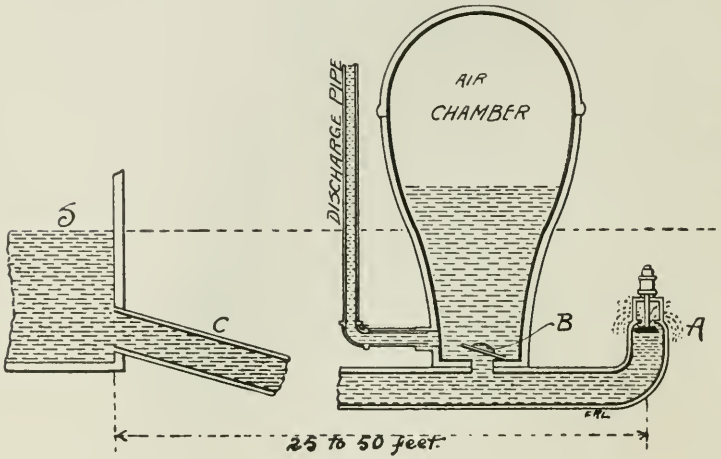


FIG. 56.

which suddenly stops the flow of water down the drive-pipe. This action of the valve in stopping the flow of water produces a back pressure in the pipe, and this back pressure lifts valve B, at the same time forcing a certain amount of water through valve B and in the air-chamber of the ram. Then for an instant water in the drive-pipe stands at rest, when valve B closes by its own weight, and also by any pressure of air or water that may be above it. Valve A at the same time falls by its own weight, as in the first place, opening the outlet, which starts the water to move through the drive-pipe again, thus repeating these intermitting actions. If the distance between the source of water supply and location of ram will not permit a straight line of drive-pipe, the necessary length of drive-pipe to produce the required velocity can be secured by using a coil containing 25 feet or more in its length.

Rule to Find how Many Gallons of Water per Minute can be Raised by the Hydraulic Ram.

Multiplying the quantity supplied by the spring (in gallons per minute) by 65; multiply this product by the "head," or the number of feet in the fall: then divide by 100 times the height to which the water is delivered. The result will give the quantity of water raised per minute in gallons or fractions of gallons. The hydraulic ram will operate with success where the fall of water is not more than two feet, but the greater the fall of supply water to the ram the greater will be its power to elevate water.

Hot and Cold Water Supply Pipes.

There are many methods of securing a water supply for a plumbing system of a building, and they vary according to location and circumstances.

In Fig. 57 we show a system largely used in country towns and places having no street supply, and in such locations it is necessary to use rain water, which is conveyed from the eaves of the roof to a tank located in the attic, as shown. Such tanks are provided with large overflow connections, which are carried to the ground and connect with a cistern, so that when the tank in the attic is filled it will overflow in the cistern; and in this way a large quantity of water will be secured in rainy times.

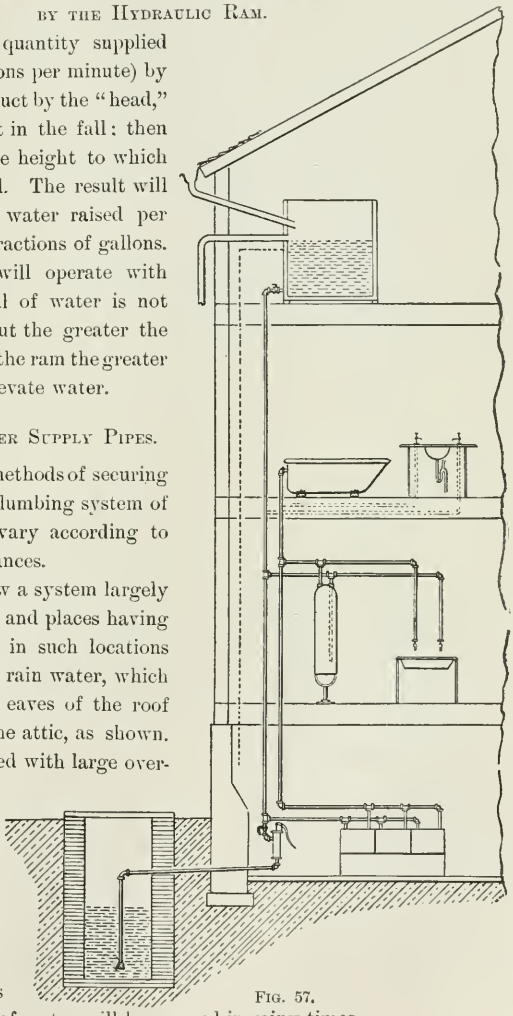


Fig. 57.

A pump is located in the cellar, which is connected with the cold water supply pipes from tank, and when the tank in attic is empty, water is pumped from the cistern into the attic tank. If the supply pipe from tank is of sufficient size it will answer as the discharge from the pump, so that it will not be necessary to carry a separate pipe for this purpose to tank. As will be noticed by referring to Fig. 57, a small pipe, indicated by dotted lines, is carried from tank just below the overflow outlet and ends in cellar. This is a tell-tale pipe, so that the operator of the pump will know when the tank is full.

The Compressed Air System of Water Supply.

Another system of water supply is shown in Fig. 58, which consists of a perfectly air and water-tight tank, located in the cellar of the house, as shown. Water is pumped from the well or cistern and forced into the tank

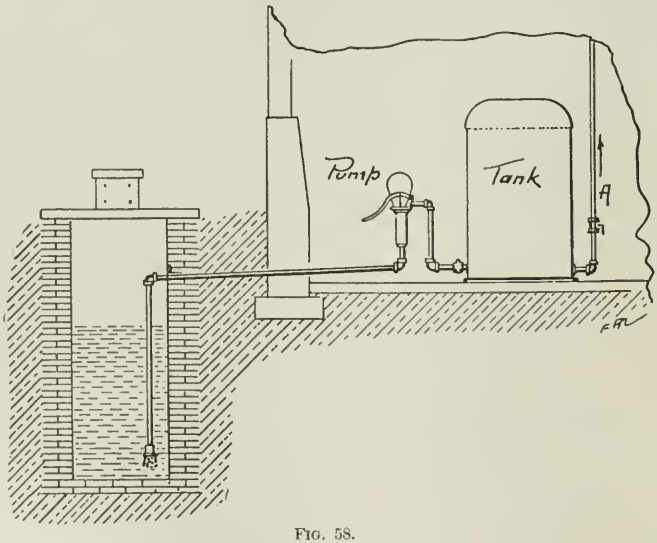


Fig. 58.

near the bottom. This connection is provided with a check-valve, so that no water can back out from the tank to the pump, and the supply of water for the plumbing fixtures pass out of tank through pipe A. A large amount of

water may be stored up in this style of tank, which will run to the highest fixtures, after once charged, for several days by the ordinary use of the water, and therefore this system is found very convenient in places where the overhead tank is not practical.

The tank is practically a large air chamber, the air remaining in the upper part of tank at all times, and with its elastic force drives the water to the various fixtures throughout the house.

Still another tank system of house supply is shown in Fig. 59. In this system all water used in the house is taken from the tank in attic, and the tank is automatically filled from the street-service pipe with a ballcock in the tank to close off the supply of water when the tank is filled. While this indirect system is a little costly, it has some good advantages. The tank supply system, as shown in Fig. 59, is especially good in places where high-water pressure must be contended with from the street mains, for the reason that the pipes and plumbing fixtures throughout the house will only have the pressure of water from the tank, and this will be even at all times, while, on the other hand, should the various plumbing fixtures be supplied direct, they would have a varying pressure, which is always bad.

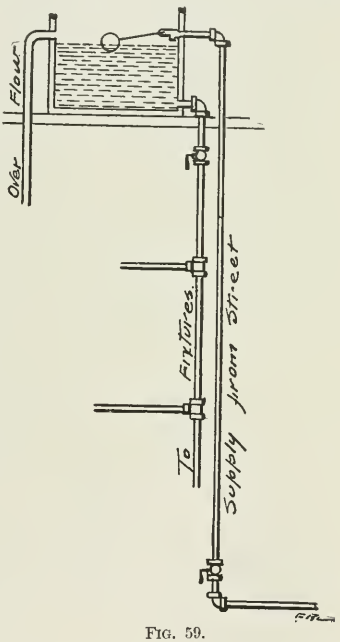


FIG. 59.

KITCHEN RANGE BOILERS AND HOW TO CONNECT THEM.

For the successful setting of kitchen range boilers, or hot-water circulating boilers of any kind, it is necessary to have a knowledge of the principles of hot-water circulation. The kitchen range boiler is simply an enlargement of the supply pipe. No matter what the pressure of water in it may be, it has nothing whatever to do with circulation. Circulation, therefore, is produced by changing the specific weight of the water in the apparatus, and this

is done by the application of heat. When water of different temperatures is found in the same vessel, the warmest particles will be located at the highest part of such vessel; and the reason of this is that the warmest particles are larger in size, and therefore are lighter, bulk for bulk. To produce circulation we must depend entirely on gravitation in the water itself being heated.

In Fig. 60 we show the most simple as well as the best method of connecting a range boiler to a waterback.

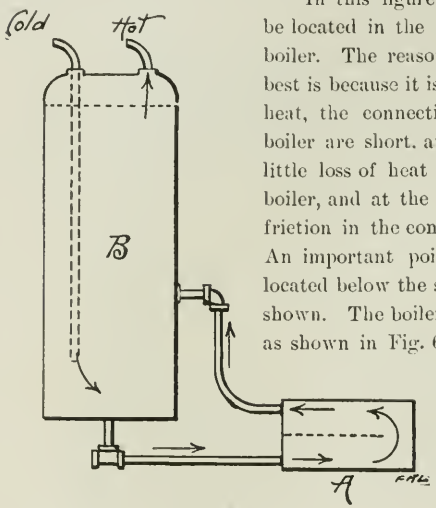


Fig. 60.

In this figure A is the waterback, as it may be located in the range, while B is the kitchen boiler. The reason why this arrangement is the best is because it is located close to the source of heat, the connections between waterback and boiler are short, and consequently there will be little loss of heat in transit from waterback to boiler, and at the same time there will be little friction in the connections to retard circulation. An important point is to have the waterback located below the side connection to the boiler as shown. The boiler is provided with four outlets as shown in Fig. 60, one at bottom, one on the side about 14 inches above the bottom in a five-foot boiler, and two openings on top.

The cold water is delivered into the boiler through one of the top connections, and on the inside of this cold water connection is placed a tube as indicated by the dotted lines in boiler which extends down within about eight inches of the bottom, so that the cold water is practically delivered near the bottom of the boiler.

The Object of the Inner Tube.

The special object in delivering water into the range boiler through a tube extending from the top is to prevent the boiler from becoming dry, which would endanger the waterback. The water may be siphoned from the kitchen boiler through the cold water supply pipe, and to guard against this

a small hole is drilled in the cold water tube near the top about $\frac{3}{16}$ in. diameter, which will allow air to pass into the pipe and break the siphon when such takes place, and thus allow the water to remain in the boiler.

Vacuum Valves on Kitchen Boilers.

Vacuum valves are used also on boilers to prevent siphonage of water from the boiler, but more particularly to prevent collapsing of light copper boilers which are not strong enough to stand the atmospheric pressure. Referring again to Fig. 60, the operation is as follows: When the boiler is filled with water the waterback and all connections will also be filled, and consequently the interior parts are solid and the water at rest, not moving in any direction, the fire is started, which begins to warm the waterback, and the instant heat radiates to the water through the walls of the waterback, that instant the circulation begins through the connections. The warm water therefore rises to the upper connection of waterback and flows to the side of boiler, and then rising to the top of boiler, while to take the place formerly occupied by the heated particles colder particles flow from bottom of boiler through the lower connection to waterback, and thus completing the circuit, which motion is continued as long as there is any difference in temperature of water in the boiler and pipes and the external atmosphere surrounding them.

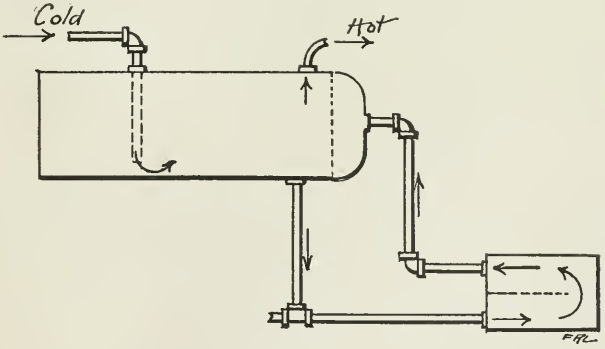


Fig. 61.

Fig. 61 shows a range boiler placed in a horizontal position, which will give the same satisfactory results as that shown in Fig. 60 as the connections

are practically the same, and this is a position the kitchen boiler is often placed through necessity.

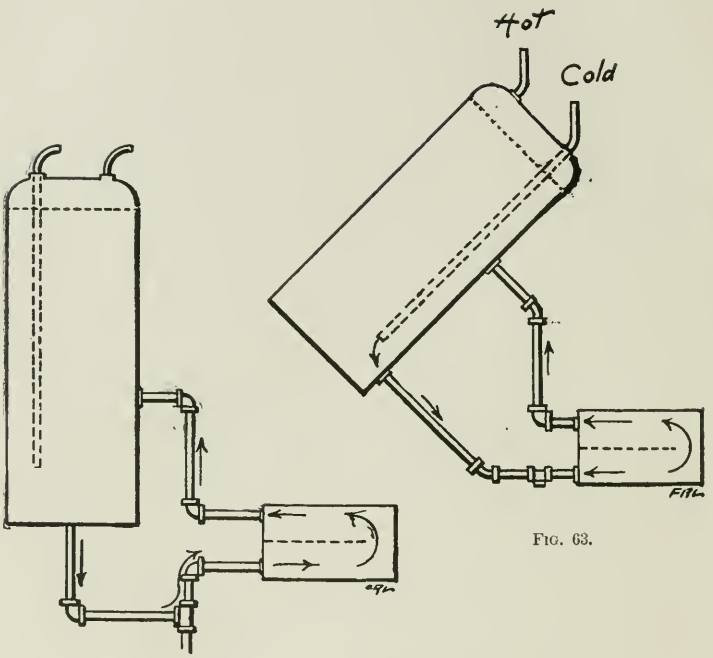


Fig. 63.

Fig. 62.

For illustration of the principle of circulation we show a boiler situated at an angle of 45°, which will also operate in a successful manner, but the pipe connections between it and the waterback are practically the same as shown in Figs. 60 and 61.

In large waterbacks there is often trouble with poor circulation, and especially under a heavy fire. This is sometimes due to the connections being too small, and in such cases the writer has found that to form a dip in the lower pipe and rising to the bottom of waterback as shown improves the circulation.

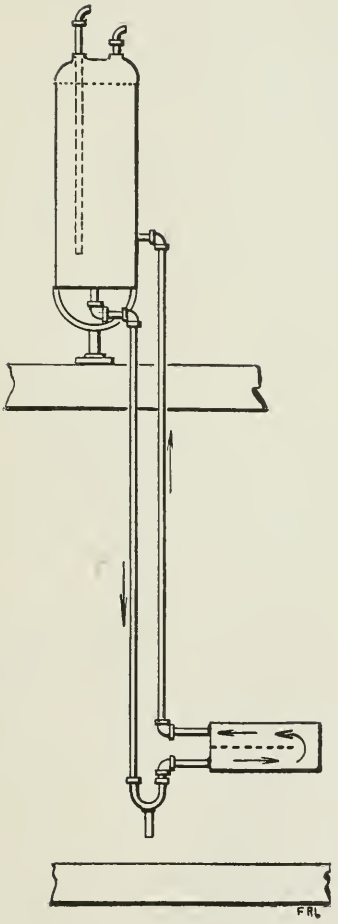


Fig. 64.

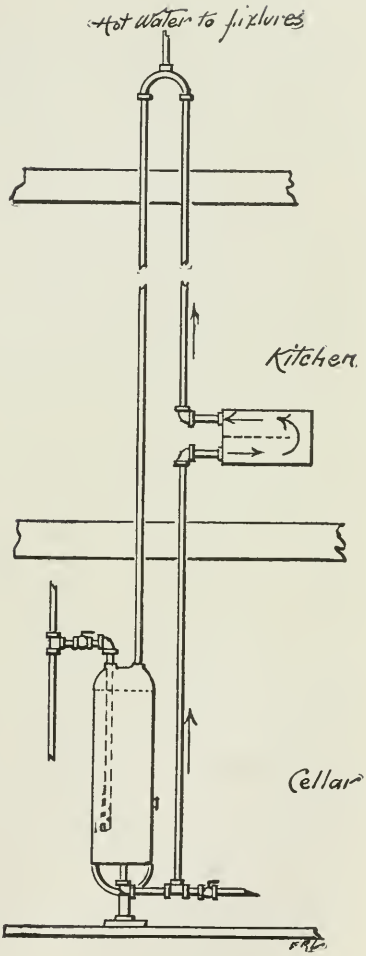


Fig. 65.

Elevated Range Boilers.

Hot water boilers cannot always be located close to the range or heater, and therefore it will be necessary to know how to place them in some other location and still have them operate in a satisfactory manner.

In illustration, Fig. 64, we show the hot water boiler located on the second floor and connected with waterback on first floor, and as will be noticed, this is done in the same manner as those already explained.

Locating the Hot Water Boiler Below the Water-Back.

As already stated the best and most satisfactory arrangement of connecting the hot water boiler is that shown in Fig. 60, yet there are times and places where and when it would be an advantage to locate the boiler in the basement or cellar below the range from which it receives its heat. And under such circumstances the hot water boiler may be so located and operate in a satisfactory manner under certain conditions.

The illustration, Fig. 65, shows how the boiler may be located below the waterback. The boiler is set in the usual manner having its inner tube and cold water connection on top and also the usual hot water outlet, and the side outlet of boiler plugged up, as three outlets are sufficient.

To deliver the heated water from waterback to boiler, it is first necessary to rise with the hot water pipe from upper connection of waterback to a height of 10 to 15 feet, then return back and connect with the hot water outlet at top of boiler, and carry a pipe from lower outlet of boiler to lower connection of waterback as shown.

All hot water must be drawn from top of loop, for the special reason that air will accumulate at this high point and would soon stop circulation unless allowed to escape as water is drawn from the hot water faucets. This system of storing hot water below the heater, is simply a deep loop or dip.

Where kitchen and laundry boilers are connected so as to be operated together or separately, satisfactory results will be obtained by following the system of connecting as shown in illustration, Fig. A. When the house supply of hot water comes from two boilers which are heated by different waterbacks, unless connected as shown, there will be trouble by having cold water pass through one or the other of the boilers which contains the coldest water. In the system of connecting as shown, water heated by the lower waterback will store itself in the upper boiler even though the upper waterback is not in operation.

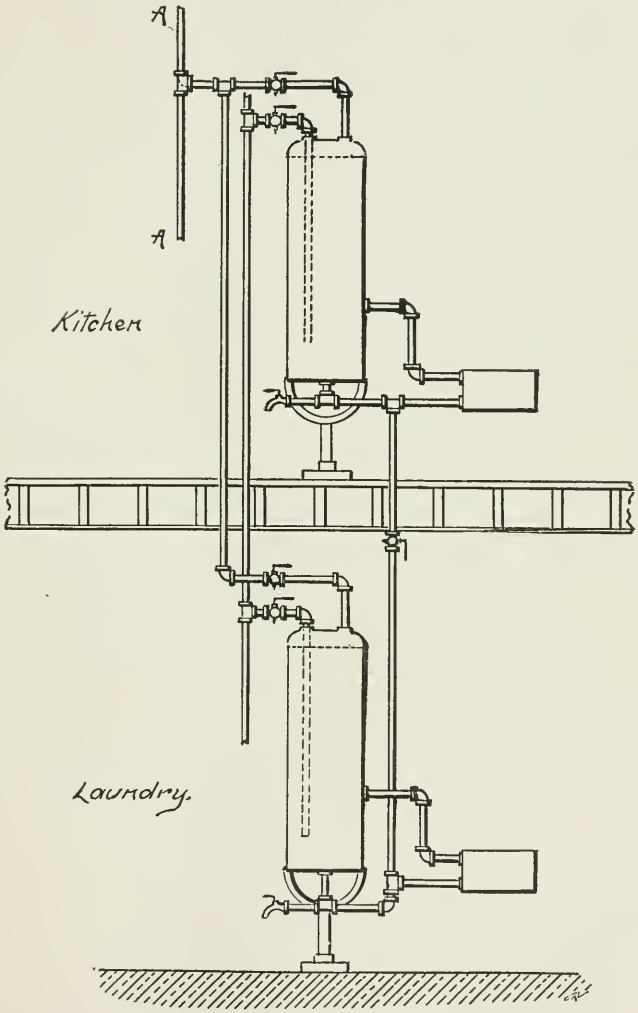


FIG. A.

Obstructions Between Waterback and Boiler.

There are often obstructions between the range and location of boiler, so that the ordinary method of connecting the pipes cannot be carried out, doors and passageways are often between the range and boiler and with such conditions, the pipe connections may be made as shown in illustration, Fig. 66, which will operate in a successful manner.

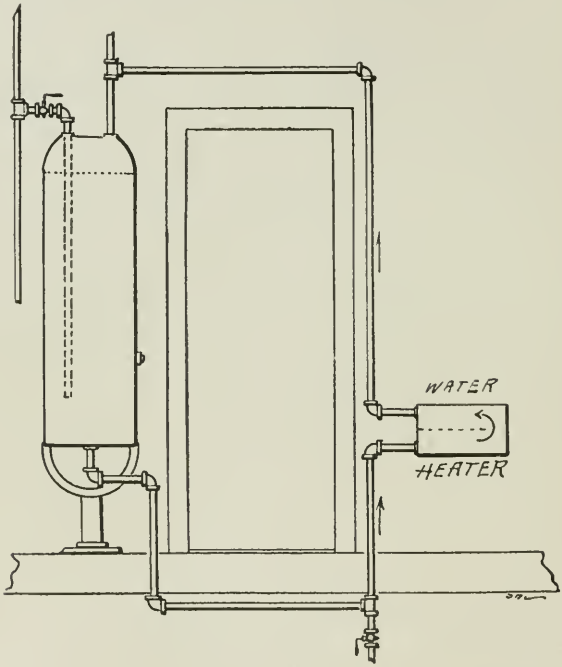


Fig. 66.

The larger the kitchen boiler the more trouble there will be with sediment, because, there being a larger body of water which holds a certain amount of mechanical matter per gallon, and special provisions should be made to take care of the sediment in at least large size house boilers. A simple method is to make both waterback connections on the side of boiler

as shown in illustration, Fig. B, and allowing the bottom of boiler to act as a sediment pocket to be drawn off at intervals.

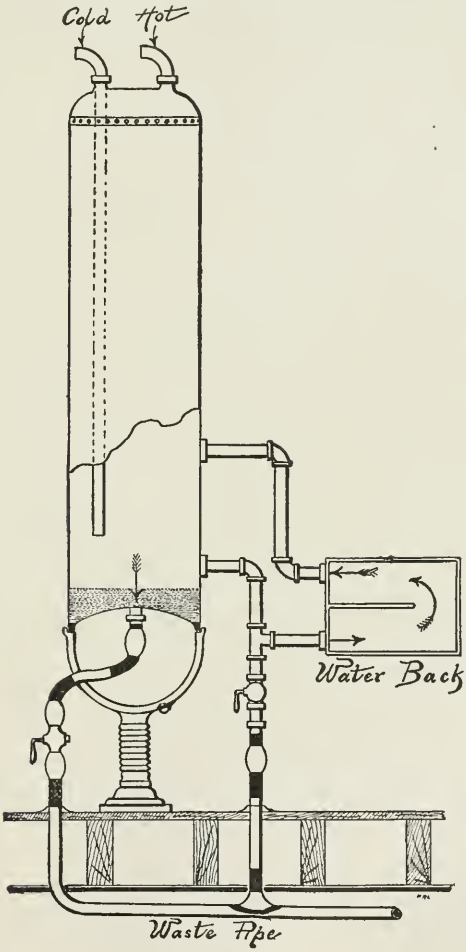


FIG. B.

Double Waterback Connections.

The plumber quite frequently finds it necessary to connect two waterbacks with one boiler with the waterbacks situated on different floors, and

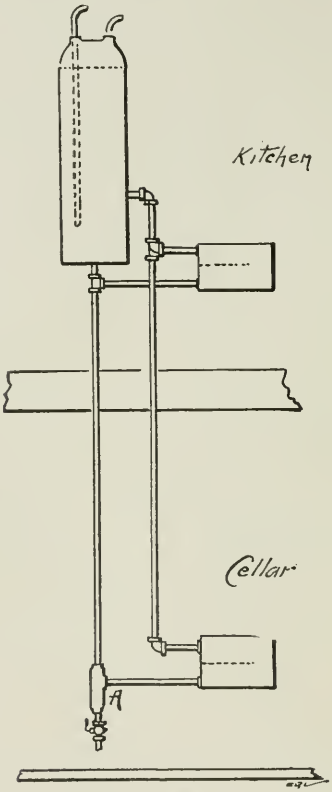


Fig. 67.

for this purpose we show the illustration, Fig. 67, by making the pipe connections as shown. Both waterbacks may be operated at the same time or either one separately with proper result.

In cases as shown in Fig. 67 it will be good practise to provide a sediment pocket below the cold water connection to lower waterback as shown at A, for the reason that all sediment from the boiler will settle at this point, unless provision is made to receive it the lower waterback will choke up in a short time.

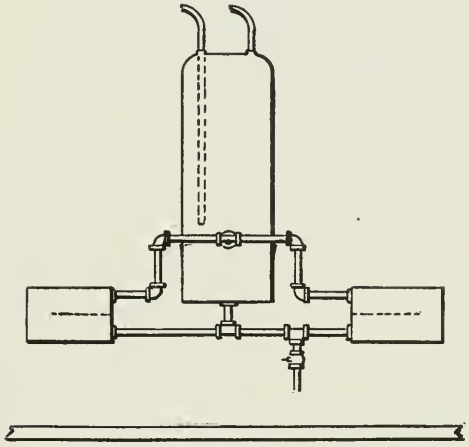


Fig. 68.

It is necessary also to connect two or more waterbacks to one boiler situated on the same floor, and the boiler may be located between the waterbacks as shown in Fig. 68, or the boiler may be located at one end of all the waterbacks and connected up as shown.

An important matter connected with all direct supplied hot water boilers is to make provision against excessive internal pressure, for the reason that the water being practically a solid, and all pipes as well as the boiler being filled with the water when in operation, there will be a pressure due to the expansion of the water which must be provided for, and when there is no obstruction in the service of the pipe it acts as a relief forcing back into the street main, but where there are water meters on the servicepipe as shown in illustration, fig. 69, at A, it will be necessary to provide a safety valve on some part of the systemwith a waste pipe connection from its outlet, it is a good plan

to place the safety valve in a place where there will be no possibility of it freezing, and therefore the top of the boiler will be a good point as shown.

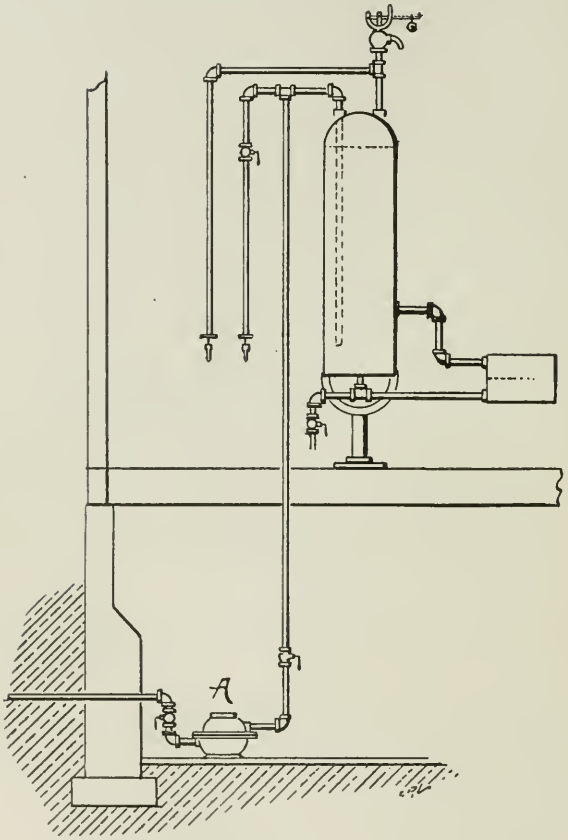


Fig. 69.

Circulation of Hot Water for Domestic Use.

The object of producing a circulation in hot water pipes connected with plumbing fixtures, is to secure warm water as quickly as possible on opening

the warm water faucets at the various fixtures throughout the house, and to accomplish this it will be necessary to extend the circulation of water through the system of the house, in the same manner as the circulation is established between the waterback and hot water boiler.

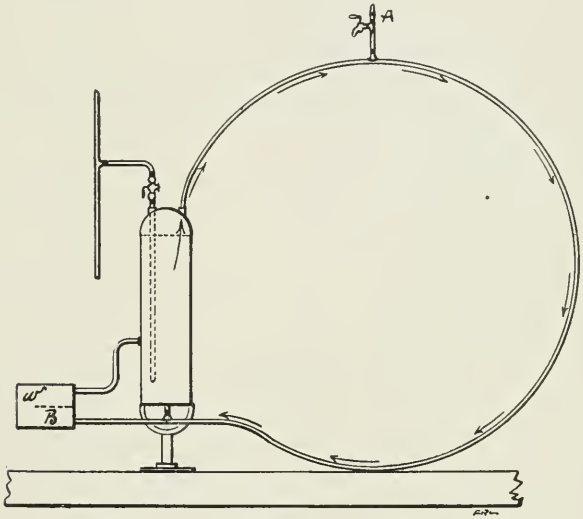


Fig. 70.

Referring to illustration, Fig. 70, this will answer to show how water moves in a circuit and also how the connections should be made. The hot water is carried from top of boiler to a point below the highest fixture which is supplied as shown at A. then returning in the form of a loop connecting again at the bottom of boiler so that the boiler forms part of the loop. The water will move around the loop in the direction of the arrows and continue as long as there is any warm water in the boiler. In a circuit of this kind there must be no chance for air to lodge in any part of the pipe as a very little air would stop the water from circulating, and this is the reason why the loop is formed a little below the hot water supply connection to some fixture, so that any accumulated air would escape whenever such faucet was opened.

Illustration, Fig. 71, shows a circulating system where the circulating pipe extends principally in a horizontal position. As will be noticed the circulating pipe connects with the hot water supply line at A and is carried back to

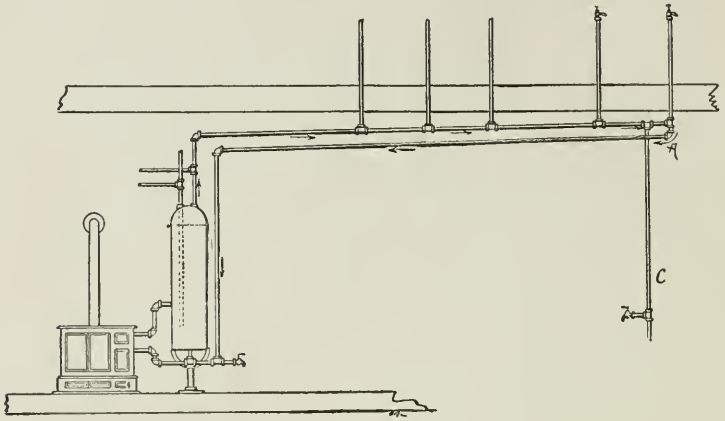


FIG. 71.

bottom of boiler as shown, for small jobs a half inch pipe would be large enough. In Fig. 71 as will be noticed a branch connection is brought down from the hot water supply pipe as indicated at C; this piece of pipe will of course stand full of cold water but it will only be to the point of its intersection with the hot water line.

In forming such circuits care must be exercised in running horizontal lines to give them some elevation from the boiler and properly supported so that there will be no possibility of the pipes sagging and forming air pockets.

In high buildings where long vertical lines of pipe are necessary the circuit is formed as shown in Fig. 72 by the dotted lines starting at A below the highest fixture and returning again connecting with the lower connection of boiler and water-back.

When plumbing fixtures are supplied from house tanks the circulating pipe may be connected as shown in Fig. 73 having an escapement for air at top of the line extending over the tank. Whether the upper plumbing fixtures are used or not the circulation will not be stopped the dotted lines being the return pipe connecting in the usual manner at bottom of boiler.

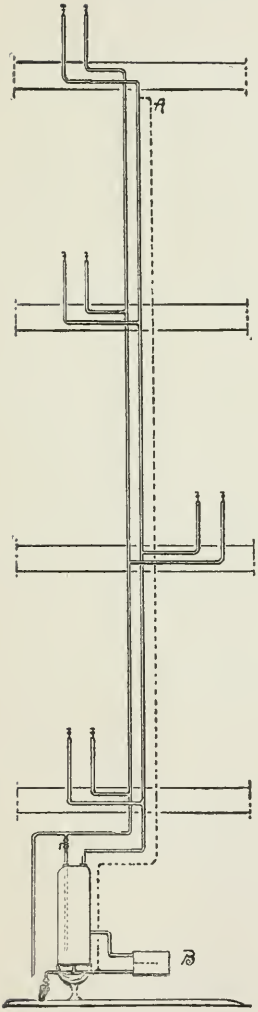


FIG. 72.

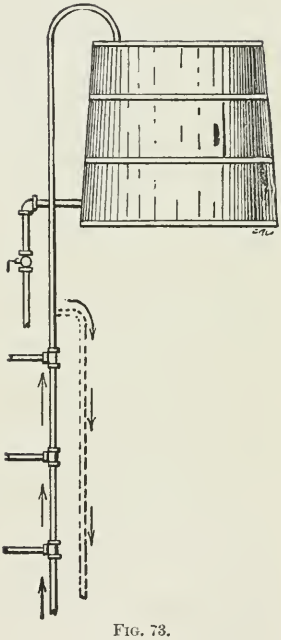


FIG. 73.

Questions by Plumbing Examining Boards and Answers to the Same.

There are many ways of describing any one thing, and a proper answer can be given to any question in a number of different ways, so it is in answering questions of plumbing examiners. What such bodies desire to know, is whether, or not, applicants for plumber's license are sufficiently qualified to carry out in an intelligent manner the plumbing arrangements of a building. so that technical names to answers are not necessary; there are no especially set questions, but such as the following may be asked by examining boards.

Q.—What is Sewer Gas?

A.—Sewer gas is air contaminated by the decomposition of foul matter in sewer and waste pipes.

Q.—What means are used to guard against the entrance of sewer gas to the atmosphere of buildings?

A.—Water seals for this purpose which are formed by bending the waste pipe so as to hold water under each water fixture, which bends are called sewer gas traps.

Q.—What other protection is there than the water seal under each plumbing fixture against the entrance of sewer gas?

A.—The ventilation of soil and waste pipes to the exterior atmosphere above the highest fixtures is also a protection against the entrance of sewer gas.

Q.—Should there be a separate trap under each fixture?

A.—Yes. Each fixture should have an independent trap.

Q.—Is a separate trap under each plumbing fixture the only traps necessary in a building?

A.—No. There should also be a trap on the main line of sewer or soil pipe and which is usually called the house trap.

Q.—Where would be a proper place to locate the house trap?

A.—The house trap should be close to inside of building wall, or near the outside of it and so located as to be easy of access and protected against frost.

Q.—May terra cotta pipe be used with safety under cellar floors as waste pipes?

A.—No. Experience has proved that terra cotta is not a safe material to be used as waste pipes on the inside of a building.

Q.—How near to the cellar wall of a house is it safe to bring an earthen or terra cotta pipe?

A.—A terra cotta sewer pipe should never be brought nearer than ten feet to the wall of a building.

Q.—Why is it necessary to extend vertical lines of soil and waste pipes their full size, after they have passed the highest fixture, to a point above the roof?

A.—It is necessary to have the full area of vertical lines of soil and waste pipes open to the atmosphere, in order to prevent siphoning of traps under fixtures at times when large quantities of water are falling in such lines.

Q.—What is meant by fresh air inlet?

A.—A fresh air inlet means a branch pipe from the house soil pipe connecting on the inside of main trap and leading to the outside atmosphere near the surface of the ground.

Q.—What benefit, if any, is there in having fresh air inlets connected with soil pipes?

A.—A fresh air inlet has the effect of producing in the lines of soil and waste pipes a circulation of air which passes in at the lower opening, and out from the top of such lines, and in so doing carries with it foul gases which are constantly forming in the pipes.

Q.—What is back ventilation?

A.—Back ventilation is to extend a separate line of pipe, from that of the soil or waste pipes, from the crown of each trap or from the sewer side of each trap, up above the highest fixture where it may connect with the soil pipe line or extend separately through the roof.

Q.—What are the best kind of pipes to use for back ventilation lines, and why?

A.—Brass or galvanized wrought iron pipes are best and most practical materials to use for this purpose; for the reason that rust scale cannot form from the surface of such, and therefore will have less chance of being choked.

Q.—What kinds of materials are used for soil and waste pipes?

A.—Soil and waste pipes are made of cast iron, wrought iron, brass, and lead.

Q.—What is meant by local ventilation of plumbing fixtures?

A.—Local ventilation means that plumbing fixtures are provided with air pipes connecting above the water seal on the house side of trap of the fix-

ture, and carried to heated flues so that a continuous current will be produced passing up from the fixtures at all times.

Q.—What is a water hammer, and cause of same?

A.—A water hammer is a noise created in water pipes, and is caused by sudden stopping of flow of water through them.

Q.—What means are used to prevent water hammering?

A.—Water hammering may be prevented by the use of air chambers placed in the pipes.

Q.—What is the cause of vibration or singing noises in water faucets and valves?

A.—Vibrations and whistling or singing sounds are caused by lost motion in some of the moveable parts of such valves and faucets, and to remedy such they must be made to fit more perfectly or tightened up.

Q.—What is the least fall that should be given to horizontal lines of soil or sewer pipes?

A.—Horizontal lines of soil or sewer pipes should never be constructed with less fall than ¼ inch to the foot.

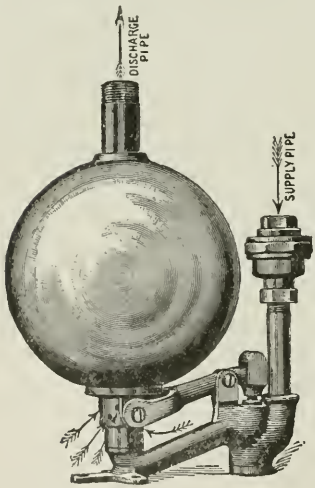


Fig. 74.

Cellar Drainers and Their Utility.

In many locations it is impossible to carry the sewer pipe into the building below the cellar floor, on account of the height of sewer in the street, and in such places the sewer will not be low enough to drain the cellar floor by gravitation, and therefore provision must be made especially in wet ground to guard against water rising in the cellar, and for this purpose the celler drainer is to-day universally used and with great success.

Fig. 74 shows the general construction of the Lawler Cellar Drainer, while fig. 75 shows one method of how these machines are utilized and connected. To lift water from a lower to a higher level requires power, and in the case of the cellar drainer water from the supply system of the house is used as the motive power.

Referring to Fig. 75 the drainer is shown set in a small pit below the cellar floor, to which the surface all round the cellar wall is pitched, so that all water will find its way to this pit. The cellar drainer is so constructed that it operates automatically starting itself as soon as water rises high enough in the pit to lift the copper float which is levered to a valve and opens same, turning on the supply of water from supply pipe A and discharging the cellar water out through pipe B into an open sink as shown, and when the water has lowered in the pit sufficiently to allow the float to drop the water is again closed off, thus preventing any waste of water from the supply except when water is being discharged from the pit.

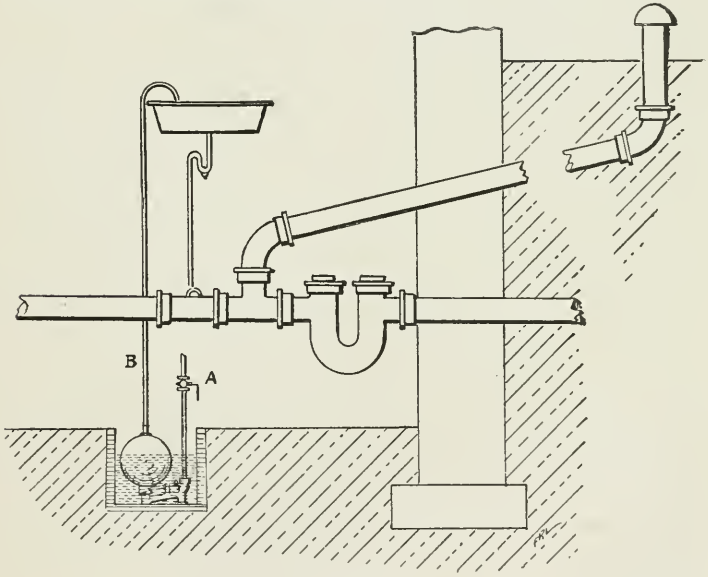


FIG. 75.

The lifting of water by cellar drainers is done on what is known as the ejection principle. A small jet of water passing through a tube produces a partial vacuum and having an outlet to the same tube submerged in water as shown in Fig. 76.

Water is drawn in by this suction produced by the velocity of the jet

and ejected to a certain height according to the construction of such machine and pressure of water supply. In illustration, Fig. 76, J is the supply pipe and S shows the inlet for cellar water to the ejector as indicated by the arrows.

Regarding the height to which such machines will elevate water and the quantity, is a matter that cannot be definitely stated because there are so many different conditions to contend with. Very much depends on the construction of the ejector, the slight difference in the size and shape of this important part makes a vast difference in the efficiency of the machine. While the machines are very useful and operate to perfection where the lift or discharge is below ten feet, they are of little value besides quite extravagant in the consumption of water when operating with greater height of discharge pipe.

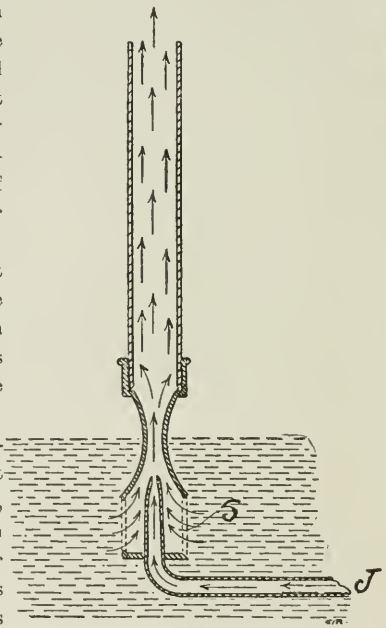


FIG. 76.

It is difficult to tell the exact amount of water any such machine will consume in lifting any given quantity, the higher the lift the less power of suction and the greater the consumption of supply water.

To sum the matter up such machines are only intended to lift water from one to about eight feet, and it is a safe plan to follow even with the best construction of cellar drainer when operated by water, is to calculate that for each ten pounds of water pressure, the cellar water can be lifted to a height of about two feet, and in this same proportion to a height of about eight feet, and above eight feet or so, the power of the machine drops rapidly.

Steam may be used to operate automatic cellar drainers with success.

Air Chambers and Their Advantages in Water Supplying Pipes.

The special advantage of air chambers in supply pipes is that they prevent a disagreeable noise known as water hammering, this noise is caused by shutting off the water suddenly and especially where the pressure is strong having part of the pipe near the fixture or faucets through which water is drawn containing air as shown in Fig. 77, is a preventive against water hammering, the space in the air chamber at A will contain air no matter what the water pressure may be and this confined air acts like a spring attached to a piece of machinery relieving the force of a heavy blow. Water being, practically speaking, a solid, while air is highly compressable, the air chamber serves the purpose well, in suddenly stopping any solid body, but the air in the chamber receives the blow and compressing by the force of the back action of the water relieves the heavy strain.

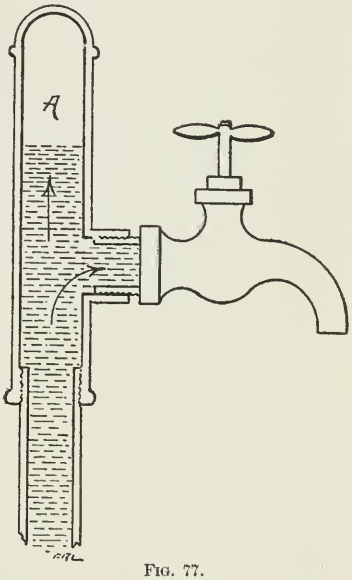


Fig. 77.

Pipes are always burst by the back pressure of water being suddenly stopped in its motion, hence the double advantage of the air chamber.

Street Service Pipes for Water.

While lead is fast disappearing as a material for water pipes in houses it will still hold its own as the kind of pipe for street service lines or any place where the pipe must be covered by earth, and even when galvanized wrought iron is used for street service work, there should always be at least a short piece of lead pipe connecting with the main pipe in street as shown in illustration Fig. 78.

When lead pipe is used under ground with much pressure, it must always

be of extra heavy quality, and great care should be exercised in covering lead pipe, so that fine clean soil only touch the lead.

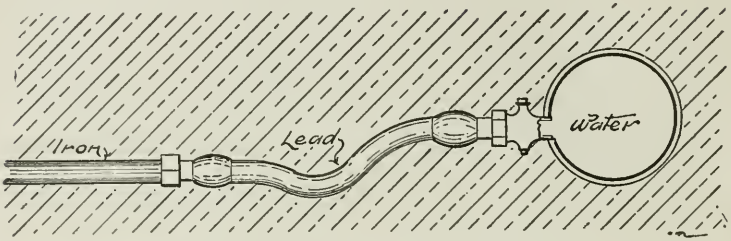


FIG. 78.

NEVER PLACE ASHES OF ANY KIND OR MANURE around water pipes to keep the frost from them as some persons often do; such packing around pipes corrode and eat away the metal and often in a very short time.

PROTECTING WATER PIPES AGAINST FREEZING.

In frame buildings there is often great trouble from freezing of the water pipes, and most of such trouble comes from vertical lines of pipe passing through floors, and outside walls; this of course means in cold climates, and practical experience of many years has taught the writer, that it is policy to exercise great care in running water pipes through floors and outside walls. If possible, water pipes should never be placed in outside walls, but where it must be done, every precaution should be taken to prevent freezing.

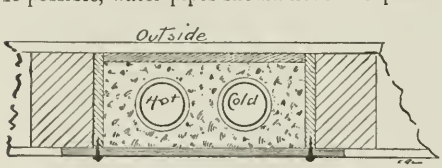


FIG. 79.

A plan which has proved very satisfactory for this purpose is shown in Fig. 79, a proper box is made between the studding in which the pipes are placed with a little space all round, and after the pipes are properly secured the space is filled with hair felt carefully packed as indicated by the dark ground between the pipes; Fig. 79 is a plan view and represents the outside frame of a house.

A place where the plumber must be careful in running water pipes, is where they pass through floors, although they may be in the center of the

house, for the reason that cold air travels from the side of house between the floor and ceiling to any point, but particularly where pipes pass through from a cold cellar near the side wall, and to guard against such trouble a box may be formed between the floor and the ceiling where the pipes pass, and filled in with hair felt as shown in illustration, Fig. 80, at H.

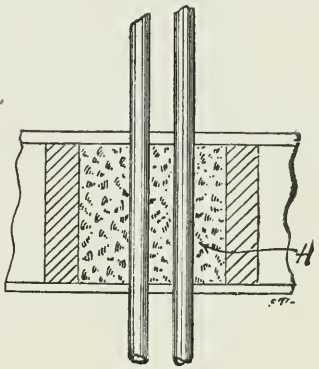


Fig. 80.

Freezing Water Pipes to Make Repairs.

The freezing of water pipes is also taken advantage of at times when bursts in the water pipes occur at points outside of the house, stop-cock, or when stop-cocks cannot be found, and this is quite frequently the case, especially in winter time when snow and ice covers the stop box at the curb or elsewhere.

Pipes cannot be frozen artificially with the water running, therefore the first thing to do is to stop the water from running in some manner or other. If the pipe is lead, flatten it with the hammer, as shown at A in cut Fig. 81, and if the pipe is iron, disconnect it and drive in a pine plug, which can be done with the least trouble. Having the pipe exposed with room enough to

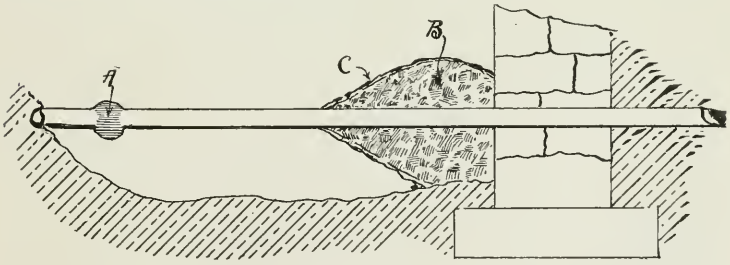


Fig. 81.

cut out for a stop-cock, prepare some broken ice with rock salt in the same manner that ice is prepared to freeze ice-cream, and placing the broken ice with the rock-salt around the pipe for about a foot in length, as shown at B in cut, then covering it over with a woolen rag, as indicated by C, letting it

stand for about one hour, the water will be found frozen solid in the pipe. Do not disturb the ice until repairs are made, and then take away the ice and apply a little hot water to thaw the water in the pipe.

The Use of Wastes in Stop-Cocks.

In running the hot and cold water pipes through a house, care should be taken to give them some fall back to the main stop-cock as far as possible, and where this cannot be done, a special outlet should be provided, so that all water can be drained by gravitation out of the pipes.

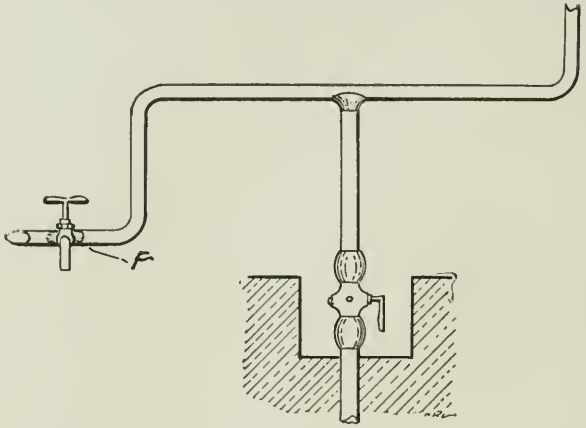


Fig. 82.

Illustration, Fig. 82, will answer to show this point. The stop-cock W should be provided with a waste outlet, so that when water is shut off from the street supply all water in the pipes above will drain out, except in such cases where branches are run, as shown at F in Fig. 82. At this point the faucet F can also be left open and allow all water in this branch to pass out, leaving all pipes in the house dry, as will be necessary when houses are to be closed up during winter time and left without heat. In such cases, the main stop-cock W must be carefully covered and packed with good hair, felt, or woolen rags, so that the water will not freeze at or below the stop-cock.

During extremely cold weather, even when houses are heated and occupied, it will be good policy to allow the water to run a little, both hot and

cold, through fixtures situated in cold places, for the reason that an ounce of prevention is worth a pound of cure.

Locating Hydrants and Other Plumbing Fixtures in Cold Places.

Cold water must be supplied at places where there cannot be heat, such as barns, stables, and outhouses, and in such cases the valve controlling the supply of water must be set below the frost line in the ground, as shown in Fig. 83 at W, all such outlets having outlets the same as in a stop and waste cock, so that as soon as the water is turned off all water in the rising pipe from valve will fall back and escape through the waste. Another important point to consider in locating hydrants or any outside valve is to be sure the soil in such location has sufficient soakage to take away the waste water, otherwise a waste-pipe will have to be provided to take away the water from the valve, and not allow it to rise to the surface of the ground, which would then freeze in cold weather and render the fixture useless.

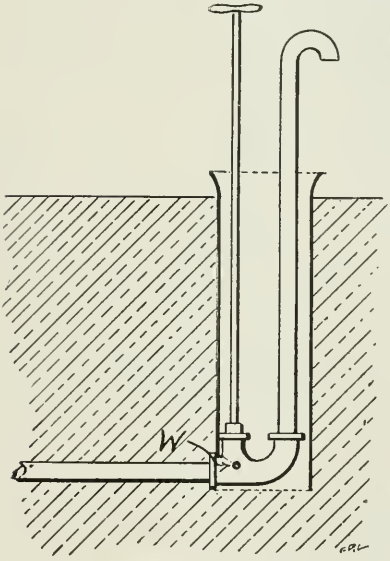


Fig. 83.

Waste Pipe Connections of Laundry Tubs.

Not the least important piece of plumbing work in the dwelling-house of the present time is the setting and waste-pipe connections of laundry tubs. As the size and often the kind of waste-pipe for this purpose the plumbing regulations of various cities and towns regulate, which the plumber must know and follow in his respective town, yet such regulations do not always clearly specify just how such work must be done, and this is true of most all other parts of plumbing work.

There is no better material for waste-pipe connections than lead, and when fitted by an experienced workman, the best results will be obtained. Lead is good for such work, because it is smooth on the inside; it is also a material that will stand the action of unclean water, and it will wear well. Besides, it can be easily bent in graceful curves to suit the situations. Such connections should in all cases be made by wipe-joints, as shown in cut, Fig. 84. In connecting to the tubs there is nothing better to use than couplings, with flanges and lock-nuts, as shown. They make a perfect joint, and cannot be disturbed by any jar the waste-pipe may receive.

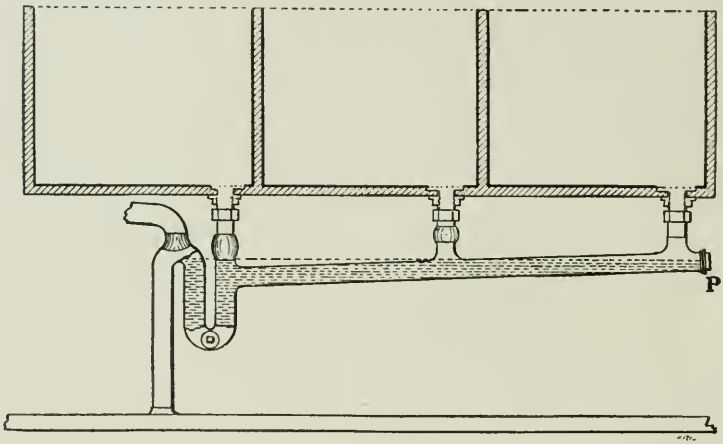


FIG. 84.

One trap for a three-part wash-tray is generally permissible by most plumbing regulations, hence we show the plan, Fig. 84. The trap should be provided with a large-size trap-screw, set on the front side, as shown, so that it can be easily cleaned when necessary. The water seal should be deep in this trap, and the horizontal line of pipe will stand partly filled with water, as shown by the dotted lines, so that a circulation of air cannot be established between the tubs. This long leg of the waste-pipe should be provided with a brass screw-plug, as shown at P, also, for cleaning.

The usual back-vent must be taken from crown of trap also, as shown, and the trap should rest on the floor by a good flange wipe-joint, which always answers as a good and safe support.

Marble Slabs and Setting Wash Basins.

It is an important thing for the plumber to know how to properly order marble slabs so that there may be no mistakes as to shapes, and for this purpose we make use of the plates 85, 86, 87, and 88.

Single Back.

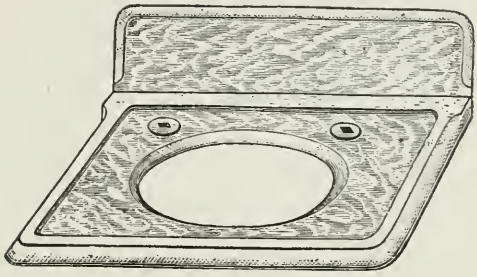


Fig. 85.

In ordering basin slabs it is a simple matter for the plumber to enclose with his order rough sketches of the size and shape of slabs desired as shown, at the same time stating whether they are to be plain or countersunk, and molded edges. Italian marble is the standard for wash basin slabs, the lower

Corner Slab.

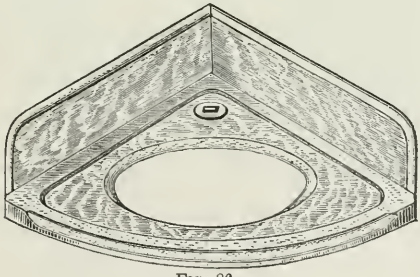


Fig. 86.

part on slab which holds the basin should be at least 1¼ in. thick. also countersunk and with molded edges as shown in plates; care should be taken in making out orders for slabs to mark the cock holes where wanted, and also whether or not chain stays are to be placed in the slab, these points con-

sidered save much trouble and time to both the marble man and plumber. Oval wash basins are now used more generally than any other shape, and this

Right Hand End.

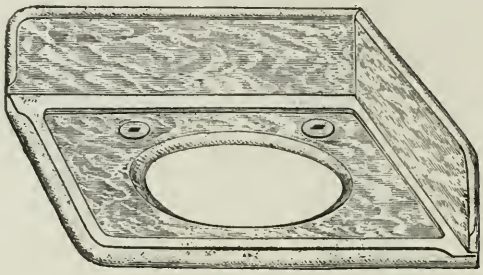


FIG. 87.

Left Hand End.

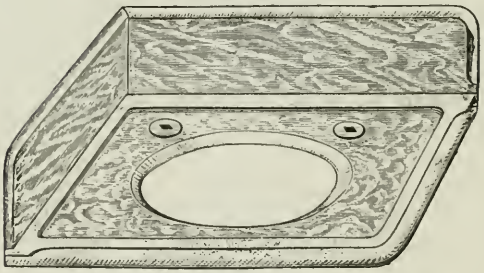


FIG. 88.

is a matter also that should not be forgotten, stating the width and length of same, while if a round basin is to be used it will be neccessary to state so, giving the size.

WASTE-PIPES FROM WASH BASINS.

As a rule the location of wash-basins necessitates long horizontal waste-pipes with but little fall, particularly in bath rooms, where the basins are at the opposite end or side of the room from the location of soil or main waste-

pipe, and on this account a short bend must be made in the waste-pipe where it passes through the floor from the basin. I desire to call particular attention to how this short bend is made, care should be exercised so that it will not be kinked, as this is the point a stoppage will occur if any stoppage takes place. As the waste-pipe runs practically flat between the joists it should have a support its entire length as shown in Fig. 89.

Traps should be connected as close as practical to the wash basin as shown in illustration, Fig. 89, and provided with the usual back vent from the top of same extending up through roof of building, or connected with soil pipe above highest fixture in attic as stated, and shown in other parts of this book.

To properly fit wash basins to marble slabs the top of basin should be ground perfectly flat, and this may be done by rubbing the basin on a flat stone with wet sand. This also takes off the glazed finish so that the plaster of paris will adhere more to the bowl. Four basin clamps should be used on any sized basin for a proper job, three are often used but they are not safe for good work.

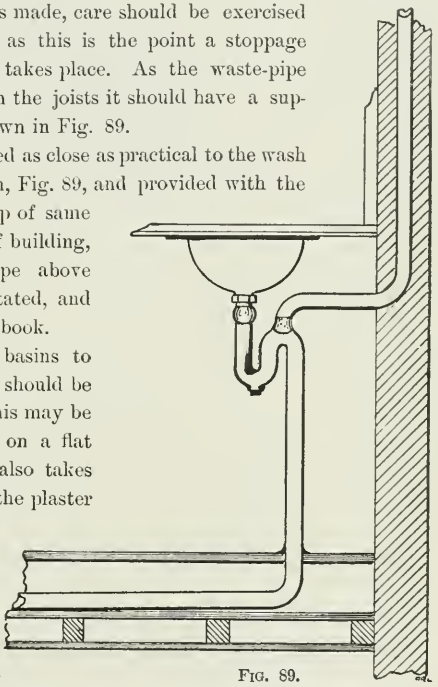


Fig. 89.

Modern Water-Closets.

A modern water-closet to stand in the front rank as a sanitary construction must possess the following points: Simple in construction; deep water seal; large water surface in body of bowl; flushing must be perfect so as to thoroughly wash all sides of the bowl; must have a quick and powerful discharge; must be economical in the consumption of water; and must be noiseless.

The points above can only be found in the style of closet known to the

trade as syphonic closets and not among all of them. The writer considers it a waste of time and space to show any old inferior make of closet or other plumbing fixture in this book as the intention is to show only the latest and best fixtures and methods of plumbing work produced at the present date.

A style water-closet which is worthy of special mention is shown in illustration, Fig. 90. It operates on the syphonic principle, holds a large body of water in bowl, and is economical in the consumption of water requiring but a two or three gallon tank. A special feature in the construction of this closet which should interest architects and plumbers, is the method by which the connection from this closet is united with the soil pipe, there being no floor joint such as used in most all other makes of closets, but the lead bend from the soil pipe is wiped direct to the outlet leg as shown.

It will therefore be seen that in this make of water-closet there is no putty joint depending on the floor for its support, the seat of this closet is fitted to the bowl, not depending on the wall for support, which renders the apparatus as completely sanitary as it is possible to be made.

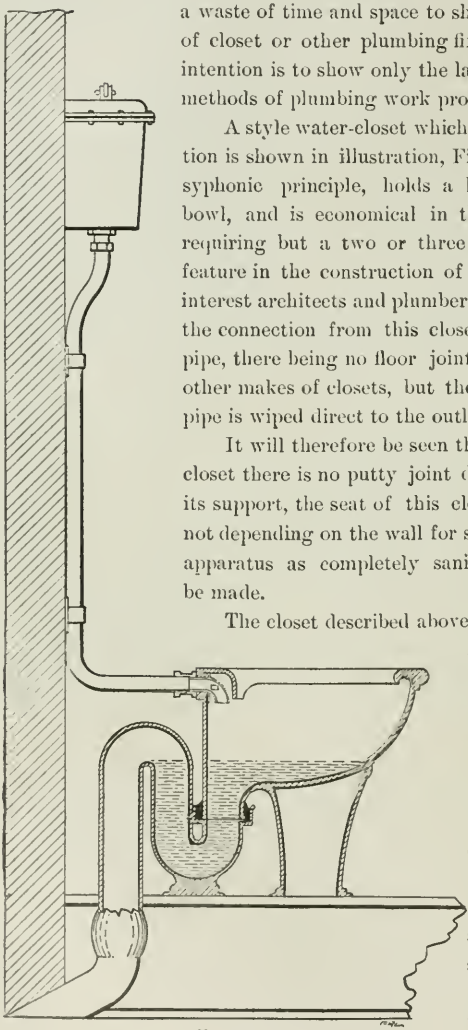


Fig. 90.

The closet described above is made by Shanks & Co., at Barrhead, Scotland, near Glasgow.

As the best style of water-closet made at the present has its trap above the floor, it must be seen that the floor connection of the closet is the most important joint to be made for the reason that such a joint will be on the sewer side of the trap and therefore should be absolutely water and gas tight under

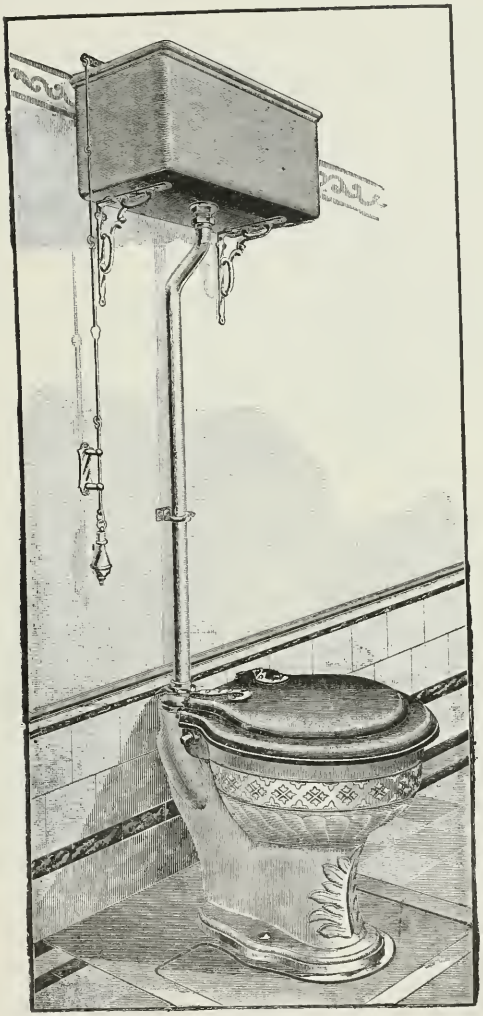


FIG. 91.

all conditions. While the water-closet shown in Fig. 91, called the Apex, possesses all the good qualities of a siphonic action with large water surface and deep trap, it also has embodied in it, a specially good feature which is the method of making the floor connection or uniting the closet in with the soil pipe.

This style of water-closets is made by Dimock & Fink Co., of New York City, and their system of floor connections is called by them their Hygienic Screw Flange.

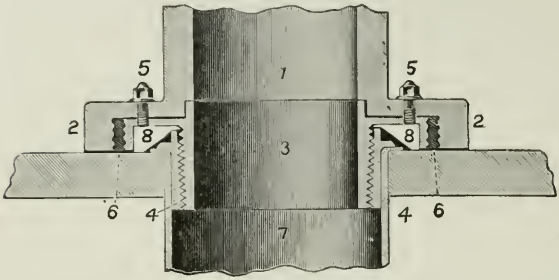


Fig. 92.

In Fig. 92 we show a sectional view of the Hygienic Screw Flange, which consists of two brass screw-threaded thimbles, each flanged on one end. No. 1, in Fig. 92, shows the lower section of the water-closet, into which the upper brass thimble, No. 3, is thoroughly united to the crockery in the shape of a calked joint, with a special compound, which is guaranteed to stand a pressure of thirty pounds per square inch.

The lower thimble mark No. 4 in illustration, Fig. 92, is united to the lead bend, No. 7, by the usual soldered joint.

In setting the water-closet, it is screwed in place in the same manner as any screw-threaded fitting, and at the same time it can be unscrewed, if necessary, with ease, and no chance of breaking or cracking the flange.

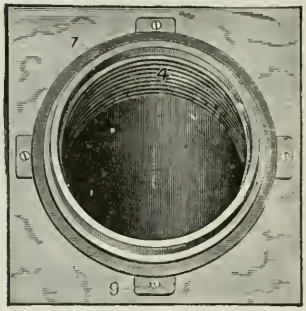


Fig. 93.

Fig. 93 shows the lower part of joint soldered to the lead bend and screwed to the floor, as shown by screws passing through lugs 9, and ready to receive the closet.

The Brass Floor Flange.

The ordinary method of connecting earthenware water-closets to the soil pipe is by a brass flange, as shown in Fig. 94.

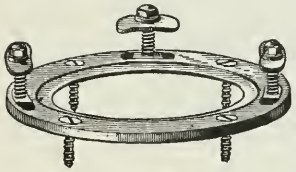


Fig. 94.

This flange is sunk into the floor or marble slab and brought level with the surface; the lead bend is brought through and flanged over the inner recess, as shown, and there soldered. This being done, the closet is set in place, using putty to make the joint between the closet and brass floor flange, while the closet is held in place by two or more bolts, which are screwed into the flange.

Putty Stains Marble.

There are perhaps more of the best make of closets set on marble slabs than on any other surface, and to guard against this marble being stained from the putty used in making the joint is a matter of importance to the plumber. A good plan used with successful results by prominent plumbers is to place a piece of thin sheet-lead under the flange of the closet, uniting it with the lead bend and extending the sheet-lead out on the marble within a little distance from the edge of the closet flange, as shown in Fig. 95 by the dotted lines A, while B represents the outer edge of closet flange.

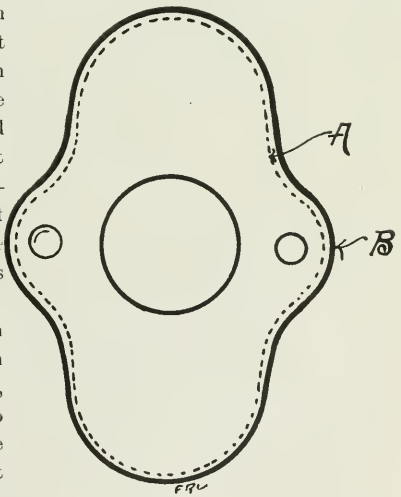


Fig. 95.

The putty may be used in making the closet joint, and then the outer edge of closet flange, filled in with plaster of paris, to make a finish, and so that the edges of the sheet-lead will not show.

By following this method there will never be a stain on the marble slab from the putty joint.

A water-closet unexcelled for good points in action, convenience, and beauty is shown in Fig. 96. This is called the Duplex Siphon Closet, and is made by Fred Adee & Co., New York City. The bowl is in a single piece of VITREOUS CHINAWARE. A feature in this closet which gives it great power in the discharge of water from it, even though the tank may be situated not more than two feet above the closet, is three separate jets or ejections, located at different points in the bowl, while at the same time being perfectly noiseless in action.

The Handy Attachment.

As will be observed by referring to Fig. 96, the ordinary dangling chain and pull are conspicuously absent, and in their place is a piece of mechanism which works with such

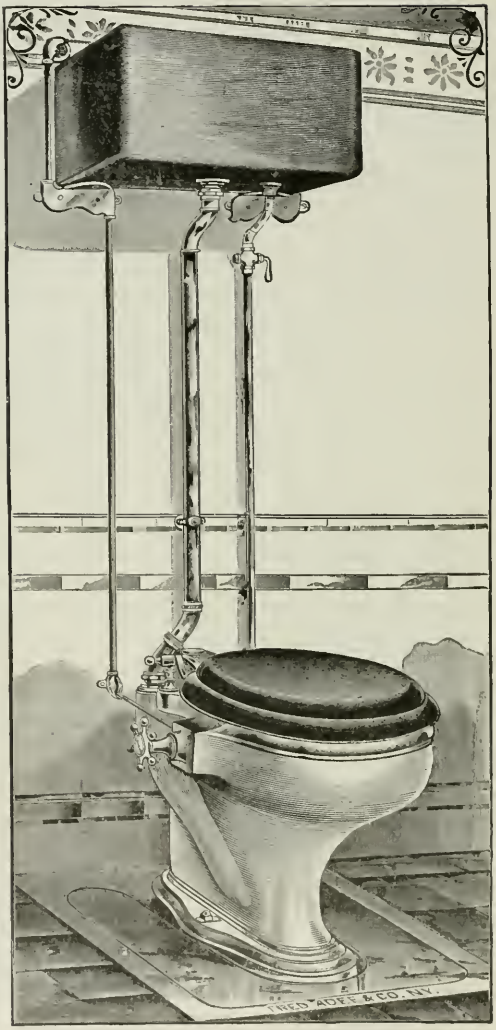


Fig 96.

ease and perfection that it would have to be used to be fully appreciated. A wheel is connected to the side of the bowl in a position that makes it unnecessary to strain one's self to reach it, as in the case of the ordinary closet pull.

The Duplex Closet, with Bidet Attachment.

In Fig. 97 we show the Fred Adee & Co.'s Duplex Closet, with low-

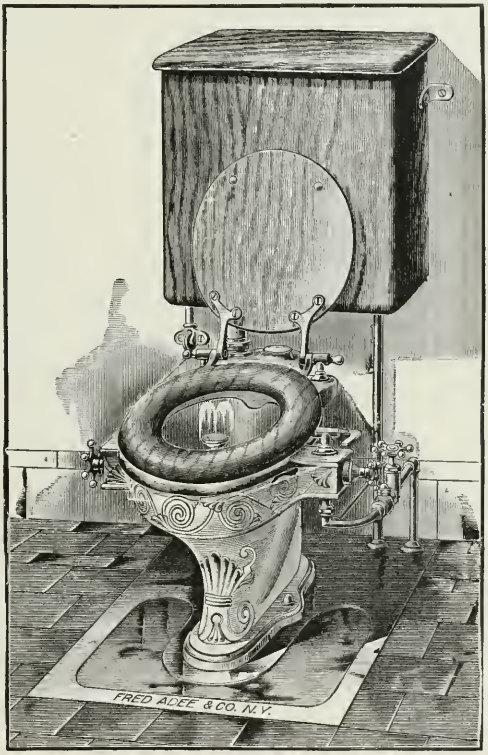


Fig. 97.

down tank and bidet attachment. This operates with the same siphonic action as that described in Fig. 96, having the handle attachment on the right-

hand side to operate the tank, while the handle to operate the bidet attachment is situated on the left-hand side, as shown. The combination, Fig. 97, is an excellent piece of workmanship, while the materials used are the best of their kind that can be produced.

Water-Closet Tank Valves.

A most important point in any tank water-closet is the tank valve, and to produce a good valve for this purpose which would meet the requirements under certain conditions has been a hard problem to solve.

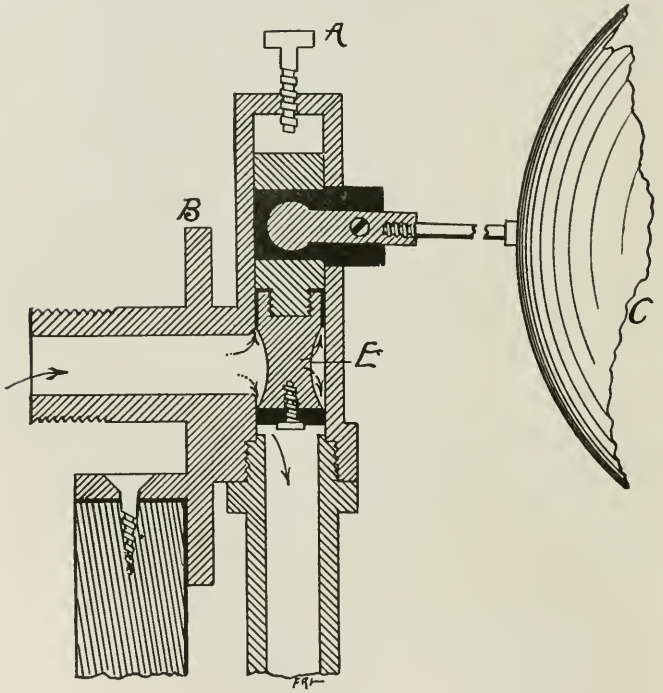


Fig. 98.

Time and experience are the only channels through which perfection in any line can be produced, and this holds good in the production of the tank valve, a sectional view of which we show in fig. 98.

This is known as Fred Adee's Balanced Tank Valve and the special points of interest in this valve which should be of great value to the plumbing trade are as follows:

The valve being perfectly balanced, will take care of any pressure of water, high or low, without requiring any extra size to float or length to the float lever. It is provided with a projecting shield on the back as shown at B, which prevents any dripping of water from passing down behind the copper lining of tank, and this is cast on the body of valve as shown.

This valve is provided with a setscrew, as shown at A, which can be used to close off the supply of water in place of a stop-cock in case of adjusting the float by simply screwing down the setscrew on to the plunger of valve E, and the fourth special feature in connection with this tank valve is that the float C is made of glass and will therefore not corrode or wear out in a lifetime. The action of this valve is noiseless under any pressure which is a most important thing in a tank valve.

Noise from Compression Faucets, the Cause, and also Remedy of Same.

The disagreeable noise so often heard throughout private houses coming from the water pipes, can generally be traced to some compression or self-closing faucet. The cause is lost motion in the movable parts of the faucet.

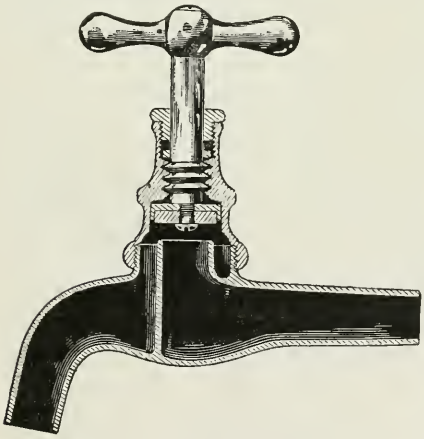


Fig. 99.

As will be noticed by referring to Fig. 99, there are two parts or pieces that move or should move independently of each other, and these two parts are the stem to which the handle is attached, and the disk at bottom of stem into which is set the washer. When a faucet of this kind is properly made the movable parts are made to fit in a perfect manner, and at the same time so that they will move easily without much pressure exerted to turn them.

When the metallic parts of such faucets are worn enough to cause vibrating, they may be temporarily remedied without removing any part, simply by screwing up the stuffing box on stem, which will hold it firm for a while, and after this a new disk and stem will be necessary.

Special Fittings for Hot and Cold Water Supply.

It is important that the plumber should keep posted on the latest and best improvements made pertaining to his business, and there is no better way to do this than to constantly read or at least glance over the trade journals. The mechanic or business man who reads the Trade Journals, is always the best posted and most reliable man to entrust with important things.

There are thousands of important improvements in the way, devices and methods of doing work of various kinds that cannot possibly be brought to the notice of all that would be interested in such things without some effort on their part, and those who make an effort to be posted on the various improvements, can as a rule do better work in less time and expense, than those of less ambition.

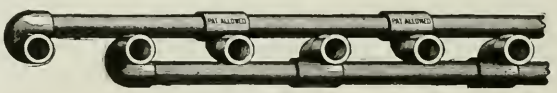


Fig. 100.

The Lawler Washtray Fittings.

In Fig. 100, we desire to call special attention to the Lawler Washtray fittings which are shown as they would be placed in position behind a three-part set of washtrays, as will be noticed the outlets are in a perfect line with each other, without having to cross the pipes. The ends of the lines, as will also be noticed by referring to Fig. 100, make a perfect finish, and in this piece of work there are three separate kinds of fittings, which would hardly be noticed unless attention was drawn to the matter. The tees shown in this figure represent one kind of fitting, while the elbows on the ends of lines represent two kinds of fittings as they are made right and left-handed. With these washtray tees and elbows the neatest kind of work can be done where outlets

Fig. 101.

from hot and cold water pipes must be carried in a line with each other, besides they save space, time, and labor.

The Lawler Straddle Fittings.

Another important fitting of recent construction is shown in Fig. 101, and Fig. 102 shows how these fittings are utilized. Where two lines of water pipes are carried in a parallel line with each other as is usually the case in running the hot and cold water pipes in the average dwelling-house, branches are to be taken from both sides of such lines, and as will be noticed by referring to illustration, Fig. 102, one straddle fitting answers the purpose of bending the pipe or using a number of extra fittings and nipples to bring the branch in line.

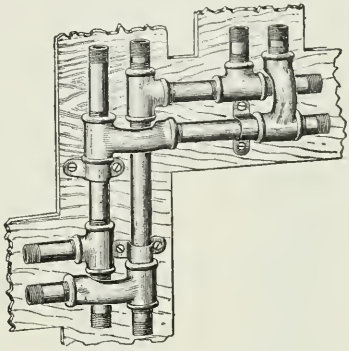


Fig. 102.

This straddle fitting is without question a time, labor, and money saving device, which can be used to advantage in thousands of situations.

We have explained in another part of this book the office or utility of air chambers in water pipes, and we therefore simply call attention to a special fitting which takes the place of a tee and an air chamber at the same time.

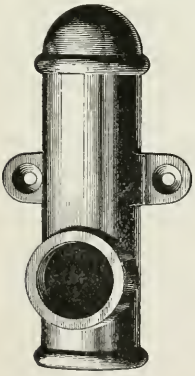


Fig. 103.

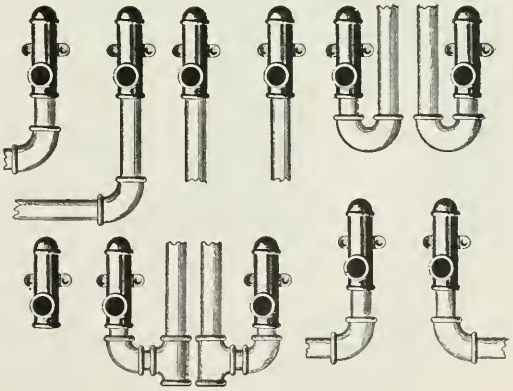


Fig. 104.

Fig. 103 was also recently produced by the author, and, as can be seen, makes a neat finish; it being in one piece also saves time and labor, and also lessens the chances of leaking compared with an air chamber formed from pipe.

In Fig. 104 we show some of the many ways by which these air chambers may be practically applied for proper results.

Special Fittings for Soil and Waste Pipe Lines.

Back venting now being a universal requirement in the plumbing regulations throughout the civilized world, that to construct in a proper manner the soil and waste pipe lines of the modern building with the ordinary old style fittings, valuable floor and wall space would be required besides the many exposed lines and branches would give an unsightly finish to the apartments. Hence the inventive plumber, quick to see where he can meet the complicated requirements, constructs special soil and waste pipe fittings a few of which we show in Figs. 105, 106, 107.

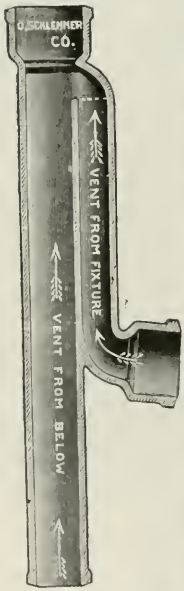


Fig. 105.

Fig. 106.

Fig. 107.

These special soil and waste pipe fittings are known as the Temple vent fittings and are make by the Schlemmer Co., of Cincinnati, O. Of these fittings this company makes a large variety to meet the various situations. Fig. 105, as will be noticed is the regular hub style of fitting for calking, while Fig. 106 is a similar fitting made with screw-threaded ends for wrought-iron pipe work. The style shown in Fig. 107 is made with outlets just below the upper hub to receive additional branches from traps when necessary.

The special feature of these temple vent fittings is that from the lower branch or outlet the fitting is practically a double pipe, so that the back vent

from any fixture where these special fittings are used will enter the main line of vent pipe at a point above the top of its respective fixture, while at the same time having a less number of joints in the pipes compared with constructing the work by the ordinary old style fittings.

Condensation on Water Pipes, the Cause and How to Remedy it.

A source of great annoyance in the average house is the sweating, as it is called, at times of the cold water pipes, and this usually occurs in summer time. It will be found that when cold water pipes run through warm places, this trouble is most noticable; and the reason of this is that at times when the air is damp and heavily charged with water, there will be several degrees of difference in the temperature of the air surrounding the pipe and the water flowing through the cold water pipe, and at such times the vapor in the air coming in contact with the surface of the cold water pipe condenses rapidly and often drips down as if the pipe leaked.

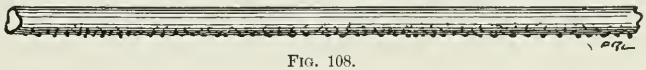


Fig. 108.

Fig. 108 represents a piece of pipe with condensation hanging from the bottom; this dripping is so bad at times that I have often seen small gutters formed from sheet metal placed under the pipes to carry off the water of condensation.

This is usually very bad in kitchens where the atmosphere is so often saturated with steam. Laundries are placed where this nuisance is allowed to exist. The remedy for condensation of cold water pipes is to cover the pipes with some good non-conducting substance, such as hair, felt, or wool of any kind.

USEFUL INFORMATION FOR PLUMBERS.

WATER.

Doubling the diameter of a pipe increases its capacity four times. Friction of liquids in pipes increases as the square of the velocity.

The mean pressure of the atmosphere is usually estimated at 14.7 lbs. per square inch, so that with a perfect vacuum it will sustain a column of mercury 29.9 inches or a column of water 33.9 feet high at sea level.

To find the pressure in pounds per square inch of column of water, multiply the height of the column in feet by .434. Approximately, we say that

every foot elevation is equal to ½ lb. pressure per square inch; this allows for ordinary friction.

To find the diameter of a pump cylinder to move a given quantity of water per minute (100 feet of piston being the standard of speed), divide the number of gallons by 4, then extract the square root, and the product will be the diameter in inches of the pump cylinder.

To find quantity of water elevated in one minute running at 100 feet of piston speed per minute, square the diameter of the water cylinder in inches and multiply by 4. Example: Capacity of a 5-inch cylinder is desired. The square of the diameter (5 inches) is 25, which, multiplied by 4, gives 100, the number of gallons per minute (approximately).

PLUMBER'S DRAWN BRASS PIPE.

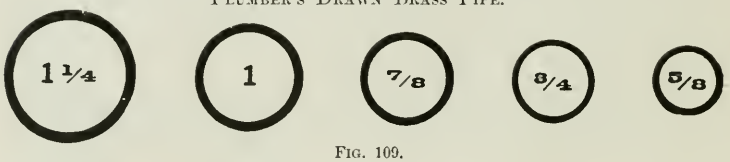


FIG. 109.

FOR PLUMBING.

Size, outside diameter, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$, 2, $2\frac{1}{4}$, $2\frac{1}{2}$.

The above tubes are made in 11 feet lengths, with coupling on one end.

IRON PIPE SIZES OF SEAMLESS DRAWN BRASS AND COPPER TUBES.

WILL THREAD TO FIT IRON PIPE FITTINGS.

Iron Pipe Size.	Inside Diameter	Outside Diameter.	Length Feet, about	Approximate Weight per foot.	
				Brass.	Copper.
$\frac{1}{8}$	.27	$\frac{13}{32}$	12	.30	.31
$\frac{1}{4}$	.36	$\frac{9}{16}$	12	.43	.45
$\frac{3}{8}$	.49	$\frac{11}{16}$	12	.58	.61
$\frac{1}{2}$	.62	$\frac{13}{16}$	12	.80	.84
$\frac{3}{4}$	.82	$1\frac{1}{16}$	12	1.17	1.23
1	1.04	$1\frac{5}{16}$	12	1.67	1.75
$1\frac{1}{4}$	1.38	$1\frac{5}{8}$	12	2.42	2.54
$1\frac{1}{2}$	1.61	$1\frac{7}{8}$	12	2.92	3.07
2	2.06	$2\frac{5}{16}$	12	4.17	4.38
$2\frac{1}{2}$	2.46	$2\frac{5}{8}$	12	5.00	5.25
3	3.06	$3\frac{1}{16}$	12	8.06	8.40
$3\frac{1}{2}$	3.50	4	12	10.00	10.50
4	4.02	$4\frac{1}{16}$	12	12.00	12.00
5	5.04	5.56	8 to 10	15.93	17.30
6	6.06	6.62	6 to 8	20.69	22.38
7	7.02	7.62	Special.	26.28	27.77
8	7.98	8.62	Special.	29.88	33.69

To find the horse-power necessary to elevate water to a given height, multiply the weight of the water elevated per minute in pounds by the height in feet, and divided the product by 33,000 (an allowance should be added for water friction, and a further allowance for loss in steam cylinder, say from 20 to 30 per cent.)

The area of the Steam Piston, multiplied by the steam pressure, gives the total amount of pressure that can be exerted. *The area of the water piston*, multiplied by the pressure of water per square inch, gives the resistance. *A margin* must be made between the *power* and the *resistance* to *move* the pistons at the required speed—say from 20 to 40 per cent., according to speed and other conditions.

To find the capacity of a cylinder in gallons. Multiplying the area in inches by the length of stroke in inches will give the total number of cubic inches; divide this amount by 231 (which is the cubical contents of a U. S. gallon in inches), and the product is the capacity in gallons.

WEIGHT AND CAPACITY OF DIFFERENT STANDARD GALLONS OF WATER.

	Cubic Inches in a Gallon.	Weight of a Gallon in pounds.	Gallons in a Cubic Foot.	Weight of a cubic foot of water, English standard, 62.321 lbs. Avoirdupois.
Imperial or English	277.274	10.00	6.232102	
United States	231.	8.33111	7.480519	

Weight of Crude Petroleum, 6 1-2 lbs. per U. S. gallon, } 42 gallons to the barrel.
Weight of Refined " 6 1-2 lbs. per U. S. gallon, }

A "miner's inch" of water is approximately equal to a supply of 12 U. S. gallons per minute.

Fire Streams.

Pressures required at nozzle and at pump, with quantity and pressure of water necessary to throw water various distances through different sized nozzles—using 2½ inch rubber hose and smooth nozzles.—G. A. Ellis, C. E.

Size of Nozzles.	1 Inch.				1⅛ Inch.				1¼ Inch.				1⅜ Inch.			
Pressure at nozzle	40	60	80	100	40	60	80	100	40	60	80	100	40	60	80	100
*Pressure at Pump or Hydrant with 100 ft. 2 1-2 inch rubber hose.	48	73	97	121	54	81	108	135	61	92	123	154	71	107	144	180
Gallons per minute	155	189	219	245	196	240	277	310	242	297	342	383	293	358	413	462
Horizontal dist. thrown	105	142	168	186	113	148	175	193	118	156	186	207	124	166	200	224
Vertical dist. thrown	79	108	131	148	81	112	137	157	82	115	142	164	85	118	146	169

* For greater lengths of 2½ hose the increased friction can readily be obtained by noting the differences between the above given "pressure at nozzle" and "pressure at pump or hydrant with 100 *feet* of hose." For instance, if it requires at hydrant or pump 8 lbs. more pressure than it does at nozzle to overcome the friction when pumping through 100 feet of

Western Systems of Fresh Air Inlets.

Having a desire to know positively how the best class of plumbing work is being done in various parts of the United States, the writer recently made a tour of inspection through many of the states examining what was considered improvements in plumbing and house drainage, and among some of the important points gathered were two systems of fresh-air inlets, as shown in illustrations Figs. C and D, which are in practical operation in the city of Cincinnati, Ohio.

Fig. C system of fresh-air inlet is without question the best that has yet been brought into use, and practically overcomes all objectionable features, with the only exception of cost which is somewhat more expensive than other systems.

In explaining the working of system Fig. C, referring to the illustration we will begin at the house trap which is set near the front wall in the usual manner and, as previously described, the first fitting inside of the house trap is placed close to trap and in place of turning out in the direction of the trap it is turned in the direction of the soil pipe coming back under the cellar floor with a slight rise to some favorable position, where it is carried up in a direct manner to a high point above the roof, as indicated by B while the soil pipe A extends in the usual manner also through the roof, but at much lower elevation.

In this system of soil pipe ventilation the circulation of air through the pipes is entirely reversed to that in the systems where fresh-air inlets are located just above the ground level; as will be noticed in Fig. C the direction of the arrows show the direction in which the air moves at all times, and under every condition of the atmosphere. In this case there can be no foul odors from the mouth of the fresh-air inlet because it is located above the roof, and, as all fresh air enters the system at the top of soil pipe lines, all air moves in the same direction through the soil pipe as that in which the water flows, which carries down to the house trap all heavy moisture and thereby getting a more rapid circulation of air through the entire soil and waste pipe system. In the ventilating system as shown in Fig. C, it is advisable to locate pipe B by the side of a warm flue so that this pipe will be kept warm which gives greater power to the circulating of fresh air through the systems.

2½ inch hose (using 1 inch nozzle, with 40 lb. pressure at said nozzle), then it requires 16 lbs. pressure to overcome the friction in forcing through 200 feet of same size hose.

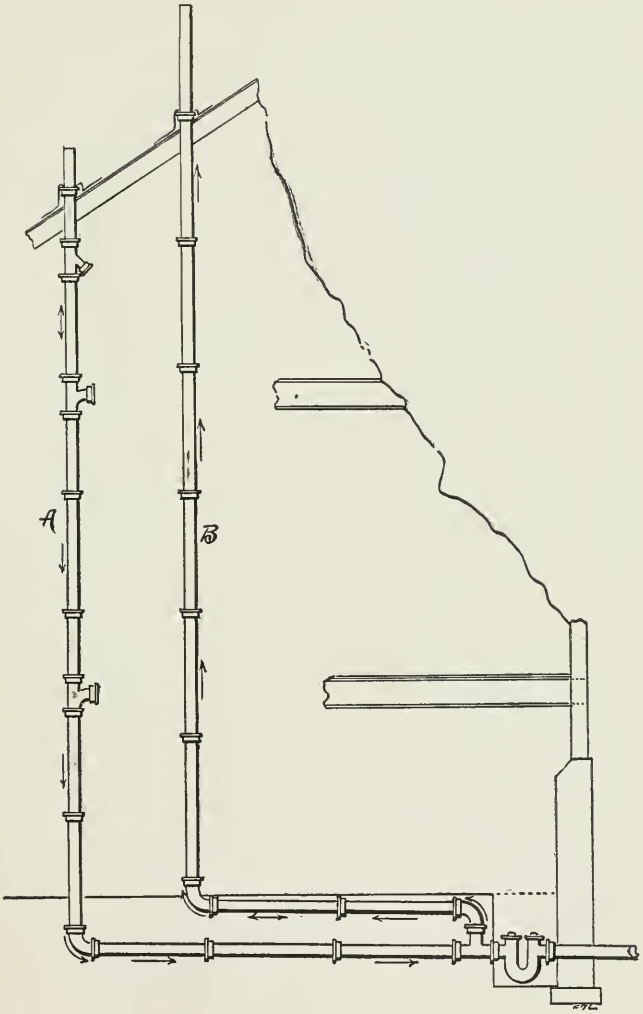


Fig. C.

The Down Spout System of Fresh Air Inlet.

Another system of fresh air inlet recently put into practise in Cincinnati for old buildings only, is that shown in illustration, Fig. D, and while it in no way compares with system Fig. C, it has some good points that might be used to advantage in many localities. The special feature of Fig. D consists of a special cast-iron fitting as indicated by A, which is set in the rain water conduction just above the level of sidewalk or outside surface of ground, having a branch which rises from the main body and returns down again with a four-inch opening at lower part of bend. This special fitting is called a down spout fresh air inlet and is made by Oliver Schlemmer at Cincinnati, Ohio; the fitting makes a neat finish, besides its mouth cannot be obstructed by dirt, wood, or stones, by children, while the best feature in this arrangement is that when water is falling through the line of soil pipe so as to force air through the branch at house trap, this air will practically

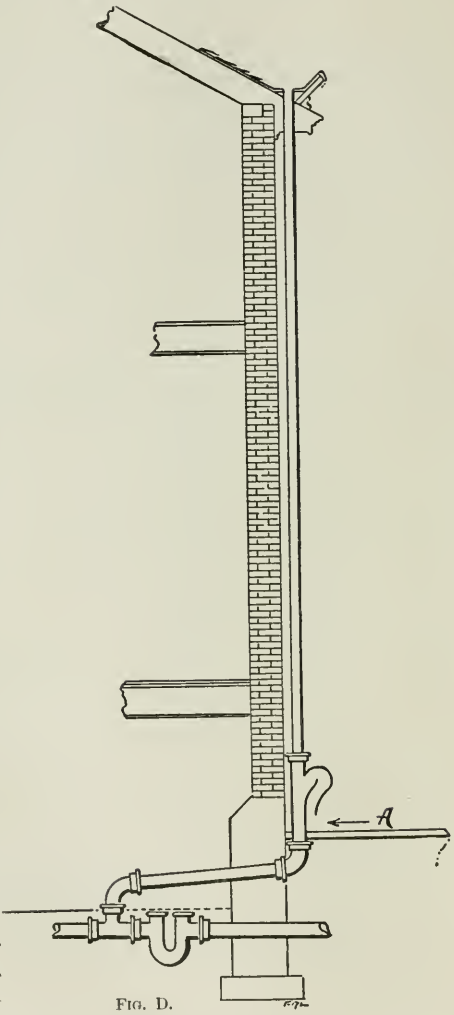


Fig. D.

all pass up through the straight line of rain-water pipe and not out through the fresh air inlet at surface of ground, while at times, under favorable conditions, there will be a good circulation of air through the system of soil and waste pipes.

THE FOLLOWING TABLE GIVES THE VELOCITY OF FLOW OF WATER DUE TO HEADS OF FROM 1 TO 40 FEET.*

Head	Velocity.	Head.	Velocity.	Head.	Velocity.	Head.	Velocity.
0.5	5.67	10.5	25.98	20.5	36.31	30.5	44.29
1.	8.02	11.	26.60	21.	36.75	31.	44.65
1.5	9.82	11.5	27.19	21.5	37.18	31.5	45.01
2.	11.34	12.	27.78	22.	37.61	32.	45.37
2.5	12.68	12.5	28.35	22.5	38.04	32.5	45.72
3.	13.89	13.	28.91	23.	38.46	33.	46.07
3.5	15.	13.5	29.46	23.5	38.88	33.5	46.42
4.	16.04	14.	30.00	24.	39.29	34.	46.76
4.5	17.01	14.5	30.54	24.5	39.69	34.5	47.10
5.	17.93	15.	31.06	25.	40.10	35.	47.44
5.5	18.81	15.5	31.57	25.5	40.50	35.5	47.78
6.	19.64	16.	32.08	26.	40.89	36.	48.12
6.5	20.44	16.5	32.58	26.5	41.28	36.5	48.45
7.	21.22	17.	33.06	27.	41.67	37.	48.78
7.5	21.96	17.5	33.55	27.5	42.05	37.5	49.11
8.	22.68	18.	34.02	28.	42.44	38.	49.44
8.5	23.38	18.5	34.49	28.5	42.81	38.5	49.76
9.	24.06	19.	34.96	29.	43.19	39.	50.08
9.5	24.72	19.5	35.41	29.5	43.56	39.5	50.40
10.	25.36	20.	35.86	30.	43.92	40.	50.72

The Plumber and His Tools.

There is a saying among plumbers, that a good mechanic is never the owner of a good set of tools. This the writer does not agree with, yet the writer has known many good practical mechanics who never used a full set of tools. Some men learn to do work with less tools than others, and can often do the same work in less time than those using double the number of instruments. The American plumber uses a less number of tools for the same class of work, so far as has been observed by the writer, than any other countryman, and it is a well known fact that the class of plumbing work done in America by what is understood to be first-class workmen, is not equaled in any country in the world. At the same time I do not believe in using a screw-driver for the purpose of lifting floors, calking soil pipe, or as a lever where a crow bar should be used, and for many other such things. There can

* Box's Hydraulics.

be no time saved in doing work with such a tool, and such work cannot possibly be done in a proper manner. I have known plumbers to do about one half their work with their pocket knife, using it in place of a shave hook, using it as a screw-driver, as a chipping knife, also for work that a good cold chisel should be used on, dispensing with the use of a saw and using the knife instead, having no use for floor chisels, forgetting that they had a hammer and using the back of the knife handle for such purpose and for numerous other purposes. This is often the cause of bad plumbing work, and not entirely because the mechanic is incompetent; if a plumber is sent to do some repair work which may be at a distance from the shop to which he must walk and carry his tools, the very first thing that comes into his mind is how many of these tools can I dispense with in order that my load may be light. This the writer has done many times when long distances had to be traveled and no trolley cars to step on to at any corner or cross road. It will be seen that there is some reason at times for not having the full set of tools on repair work. Nevertheless, I advocate the principle of having a proper and a sufficient set of tools to properly execute the work, no matter what the trouble may be in conveying such tools to the work. This brings to my mind cases where the quality of material was of cheap grade and simply on account of the mechanic's efforts to make his load light. It often happens that work is to be done at a distance from the shop, and as stated above to which place the plumber is required to walk and carry not only his tools but such materials as may be required for the work. If it happens to be a lead waste pipe that is to be renewed from a sink or other fixture, and which should be of good strong quality, say for example what is known to the trade as C lead waste pipe, and the proper diameter of same should be 1¼ inches, the shirking plumber will select for the work not C, but D or even E lead waste pipe, and not 1¼ inches, but 1 inch in diameter and just because he does not care to carry the little extra weight in the pipe. This sort of doings is of great injury to boss plumbers who must be responsible for the work of their men, it is therefore important that such workmen should be properly looked after on all such matters of this kind.

It is the duty of the man in charge of any plumbing shop to know for sure from time to time that every mechanic who is expected to erect or construct plumbing work, has a proper set of plumbing tools, and in proper order.

It Does not Pay to Have Poor Tools.

Valuable time is often lost on account of poor stocks and dies for cutting and threading brass and iron water pipes, and where bad dies are used the threads cannot be good, and the result is also leaky joints, so that there is not only time lost in trying to thread such pipes with practically worn out dies, but valuable time is lost in putting such pipes together, and afterwards trying to stop leaks in them. While speaking on the subject of tools it is also well to mention the matter of vise for holding pipe. There are also special tools of this kind for special work, and it is nonsense to think that polished brass or nickel plated brass tubes can be properly handled with ordinary tools for iron pipe work. And this is especially so in regard to holding such pipes for the cutting of threads. Therefore special vises, for holding brass pipe should be used, and no good plumbing establishment should be without at least one of these tools.

In Fig. E. we show a recent construction of vise for holding polished brass tubes, and which it is said will not mar the surface of such tubes in the slightest degree, and as there is now so much polished brass pipe used in plumbing work, a tool of this kind is practically indispensable.

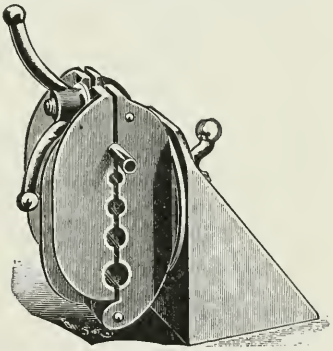


Fig. E.

The vise shown in Fig. E. is manufactured by the Hollands Manufacturing Company, of Erie, Pa., who also make special tooled steel dies for threading brass pipes and tubes.

A Practical Illustration of the Temple Vent Fittings Compared with the old Style Pipe Work.

By referring back to page 100 it will be noticed that we have described the temple vent fittings in a brief way, and we here show by sketch, Fig. F, these fittings placed in position on the back vent line of plumbing fixtures. And we show also a similar sketch in Fig. G as executed with the ordinary style of fittings.

There are many persons who hesitate a great deal before they will give

any consideration to a new device, no matter how much of an improvement it may be over any older device or method. And for this reason I desire to

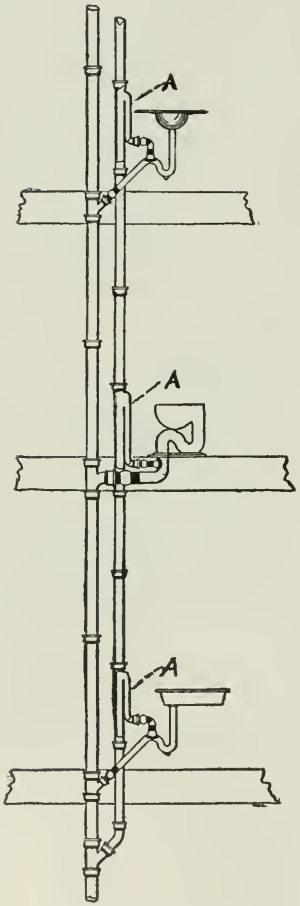


FIG. F.

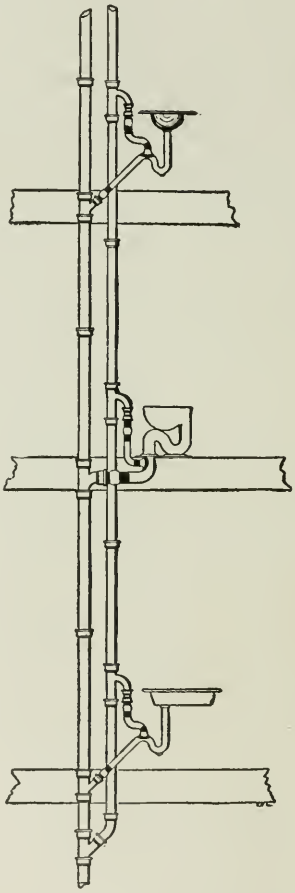


FIG. G.

point out to the plumber and architect who should be interested in any im-

provement pertaining to plumbing work, the advantage of this particular fitting when used on back vent lines of waste pipes.

As stated on other pages the modern method of carrying back vent lines from the crown of each trap to a point some distance above its respective fixture before entering the main vent line, it necessitates, as will be noticed by referring to Fig. G, three separate lines of pipe by the old method from the floor to a point above the fixture. And as these three lines cannot be placed absolutely close to each other, as they each have hub joints, which must have sufficient room to calk same, it will be seen that a large amount of valuable wall space is taken up which again necessitates the cutting of either woodwork or brickwork in the walls or partitions, that will tend to weaken same more or less. By observing the style of work in Fig. F, where the temple vent fittings are used, it will be seen that by the use of these fittings there are only two lines of pipe from floor to a point above each fixture, while the same object is accomplished as aimed at in Fig. G with less room taken up, and less cutting of walls to be done, and very naturally much less time required in constructing the work by the use of the new fittings. In Fig. F A-A-A indicates these special back vent fittings, and as will be noticed where connections are taken from water-closet branches below the floor, extra long fittings are made which extend above top of closet bowl, while fittings of this kind used in connection with sinks and wash basins are made of shorter length to correspond to height of trap under such fixtures.

Fig. H.

The Sisson Insertable Joint.

A most ingenious improvement in the way of a special fitting also used on soil pipe work is shown in Fig. H, and which is specially intended to be used where repairs or changes are to be made in lines of soil pipe.

The Sisson insertable joint consists of a section or short length of pipe having a deep or extra long hub, as will be seen by referring to illustration Fig. H.

It often happens that vertical or horizontal lines of waste and soil pipe are to be tapped for special branches after such lines have been completed, and in use, and to take out the soil pipe from one end or down from roof to point where such branch was required, would entail a considerable expense. And should

the pipe be disconnected at the point where connection was required without starting at one end of the line, at least a whole length and most likely two lengths would have to come out, in order to get sufficient movement to place the new connection and soil pipe in line again. This also is expensive, not only on account of the number of feet of soil pipe required, but the extra amount of time necessary to make such changes by the old method. By the use of this new fitting, it will only be necessary to cut out of the line of soil pipe for the purpose of inserting an extra tee or y branch as the case may be. A part of one full joint of soil pipe as may be noticed by referring to Fig. I, on the right side of cut, while the bent line in Fig. I shows the old method of joining such connections.

It will also be noticed by comparing these two methods of connecting soil pipe lines that four joints are to be calked in the old method, while only two are necessary by the use of the insertable joint. This means several pounds extra lead and oakum as well as the extra amount of soil pipe and time compared with the new method. Therefore there is no plumbing shop that uses cast iron soil pipe that should not have these new fittings among their stock.

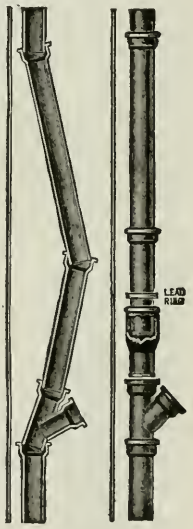


Fig. I.

Testing Soil Pipes.

As briefly stated in another part of this book, all soil and waste pipes should be thoroughly tested before considering the work safe for use. And now that the health boards of nearly all important cities of this country have awakened to the great importance of the most exacting sanitary laws and regulations that the testing of soil and waste pipes in buildings is compulsory. Therefore, for the plumber's own protection, to guard against the loss of time and material due to imperfections in soil and waste pipes, it is of great importance to use only the best quality of soil pipe, both as to weight and grade of iron in same. For the conveying of soil and waste water through houses, the quality of soil pipe known to the trade as extra heavy is none too good, but in no case should a lighter weight of soil pipe be allowed in buildings for this purpose. The

plumber, before setting his soil pipe in line to be calked, should carefully examine each length and fitting, not only to guard against cracks or splits, which often exist in new pipe, and are exceedingly hard to find, but to discover if possible any sand or blow holes in such castings. Soil pipe cannot be thoroughly examined for these purposes unless clean, and therefore soil pipe should not be allowed which is coated with tar before the pipes are set in place and thoroughly tested. There is no advantage in coating soil pipe with tar or anything else, where such pipes are used above the ground in buildings, for the reason that the exterior surface of such pipes in such location will be dry and practically no rust sets in on such surface, and as such pipes are

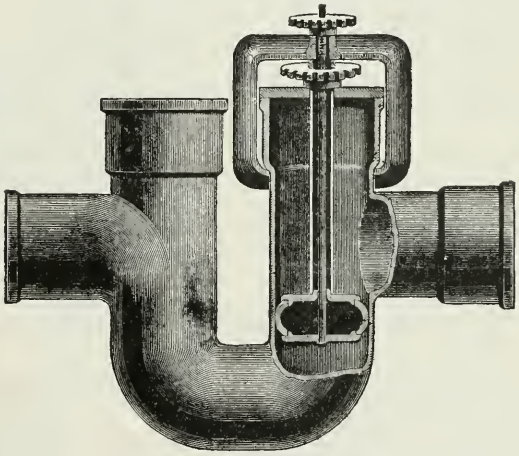


FIG. J.

usually enclosed in walls and partitions there will be no necessity to coat them on the score of appearance. After soil pipe lines are completed with all branches taken out for the fixture connections, the next step will be to close the openings in such soil pipe stacks and lines, beginning at the house-trap, so that all pipes from this point to the outlets above the roof will hold water. At this stage of the work it will be necessary to provide adjustable stoppers for each opening that can be quickly put in place and also removed with ease after the tests are completed. And as it is the rule and requirement in many cities to allow the water to stand in all soil pipes for twenty-four hours before

the test will be considered sufficient, it will be seen that the best kind of stopper for this purpose will be none too good.

In illustration, Fig. J, we show a make of soil-pipe stopper which appears to meet the general requirements, as it can be adjusted to fit any ordinary style of pipe and fittings. In Fig. J it may be noticed the stopper is shown in place cutting off the outlet from the house trap. The stopper consists of a flexible end which is inserted in the opening, possessing two rods, one within the other as will be noticed, having an adjusting screw at upper end which passes through a clamp. The lower part of stopper being flexible on sides, with metal plates on upper and lower part of same, which are less in diameter than the pipe, allows the instrument to pass in with ease, and when placed to the proper position the adjusting screw on top of rods is screwed up, which carries with it the lower plate of flexible end, and as the top plate cannot move, the flexible sides are forced out against the walls of the pipe, thus closing same perfectly against the escapement of water. Where the ends of openings are to be closed, such as branches of soil and waste pipes, a flat rubber stopper is forced against the ends of such branches, as shown in Fig. K, which are easily and quickly applied, at the same time making a perfect water-tight joint. These special soil-pipe stoppers are known to the trade as the Climax, and are manufactured by the C. M. Kemp Mfg. Co., of Baltimore, Md.

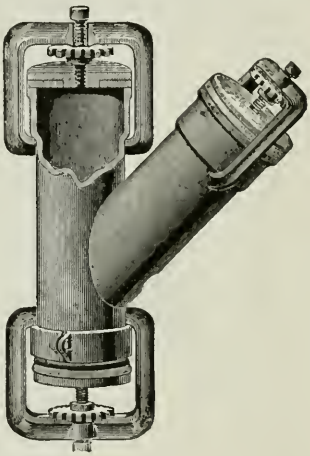


Fig. K.

The Soil Pipe Must be Filled with Water.

Having all the openings closed in the soil and waste pipes, they are then filled with water to the outlets on or above the roof, and this is usually done by the use of a rubber hose which conveys the water through the mouth of one of the vent stacks above the roof, and at times it is found more convenient to connect the water supply pipe to some of the openings in soil pipe and fill same in a direct manner.

In New York City the law requires that the soil pipes must stand filled with water for twenty-four hours, and if any imperfections are discerned they must be remedied, and the same test repeated until the entire system is found to stand tight.

The Smoke and Peppermint Test.

Soil and waste pipes are also tested by the use of smoke and peppermint, also other liquids and gases, but these tests are usually employed on old work, where the fixtures are attached, and it is also important to use such tests after even new work has been completed. When peppermint is used for this purpose, it is necessary to have all traps filled with water to their proper level. Then an ounce or two of essence of peppermint is placed in the soil pipe system usually through one of the vent openings above roof, and at the same time, a few gallons of hot water are also poured in, care being taken not to allow any of this water to flow into the traps, for the reason that, should this hot water contaminated with essence of peppermint enter the traps and mingle with the water of the traps, the odor of peppermint would be readily noticed in the rooms, for the reason that it would pass through the trap's seal and thereby make it impossible to tell whether or not it escaped through an imperfection in the pipes.

For the reason given above there is no better test for soil and waste pipes with fixtures attached than the smoke test.

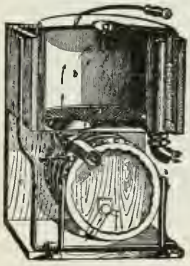


Fig. L.

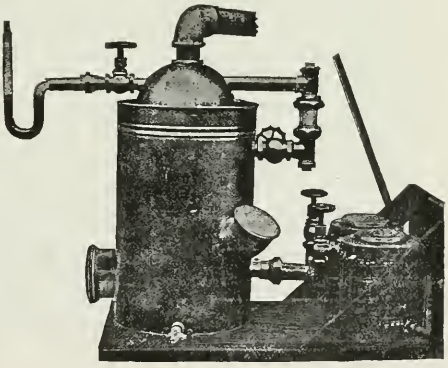


Fig. M.

There are a number of specially constructed machines for the purpose of generating smoke and forcing it into the pipes to be tested, some of which we show in the following illustrations.

The illustration, Fig. L, shows a smoke testing machine of modern construction which is put up in compact shape and constructed of copper, which makes it durable against the corroding effects of smoke and acids. This machine is known to the trade as the Thompson Smoke Tester, and is manufactured by Gunster & Forsyth, at Scranton, Pa.

Another style of smoke tester is shown in Fig. M, which is made by the Milton Smoke Testing Co., of New York City. This machine is also well known among the better class of plumbers who speak highly of its qualities.

The Chemico Drain Tester.

Briefly described, the "CHEMICO" consists of a rectangular receptacle and pressure fan. In this receptacle are placed several independent trays which contain volatile and pungent liquid chemicals. As soon as this has

Fig. N.

been effected and the apparatus closed, the gases form a new combination different in character and physical properties, creating smoke of a very pungent nature. The new vapor formed is dense and yet diffusible, and has unmistakable qualities which make it a most valuable adjunct in the work of

discovering defective plumbing. After all the open ends of all pipes are temporarily closed, this vapor is forced through the pipes in all parts of the house by the mechanical pressure fan in the "CHEMICO" and no break or fissure, however insignificant, escapes detection. These being definitely located by sense of both sight and smell, their extent can be readily ascertained and the remedy applied.

The illustration, Fig. N, shows the Chemico drain tester rigged on wheels similar to that of a tricycle, so that it can be taken from place to place with both ease and comfort.

The above machine is made by the well known plumbing firm of Rossman & Bracken, New York City.

What the Smoke Test Shows.

It shows any defects of material in iron soil, waste vent pipes and fittings such as sand holes, due to imperfect casting, or splits and cracks caused in handling.

It shows any defects in joints due to improper workmanship or accident.

It shows if soil and waste pipes are free from stoppage.

It shows if vent lines are free from stoppage—due to accumulation of rust or other foreign matter.

It shows the improper connection of vent lines with the systems of soil lines. This is very important, as an inexperienced or careless workman very often connects one of these lines on the wrong side of a trap, thereby forming what is called a by-pass which allows the free access of sewer gas into the building although the fixtures may be trapped.

It shows if all connections between fixtures and the soil or vent lines are made perfectly tight. This is a most essential feature, as in the case of new work these connections do not come under the water test required by Department of Buildings.

It shows if the surface or area drains have been properly trapped, thereby preventing the entrance of sewer gas to living rooms through open windows or cold air ducts supplying heating apparatus.

It shows if all fixtures throughout building have been properly trapped.

It shows if the seals in all traps are properly maintained. This is a very important feature, as traps are often imperfectly constructed, defects in same

exist, or by the lodging of some foreign substance, loss of seal is caused by capillary attraction.

It shows if the vent, soil or waste pipes are carried through the roof of building in a manner to prevent the down draughts of sewer gas through open windows, chimney flues, fireplaces, etc.

It shows if the vent, soil and waste pipes discharge in such a manner above roof as to contaminate the water supply of a building when a roof tank is used.

It shows if all leaders are properly trapped, thereby avoiding the entrance of sewer gas into building through open windows.

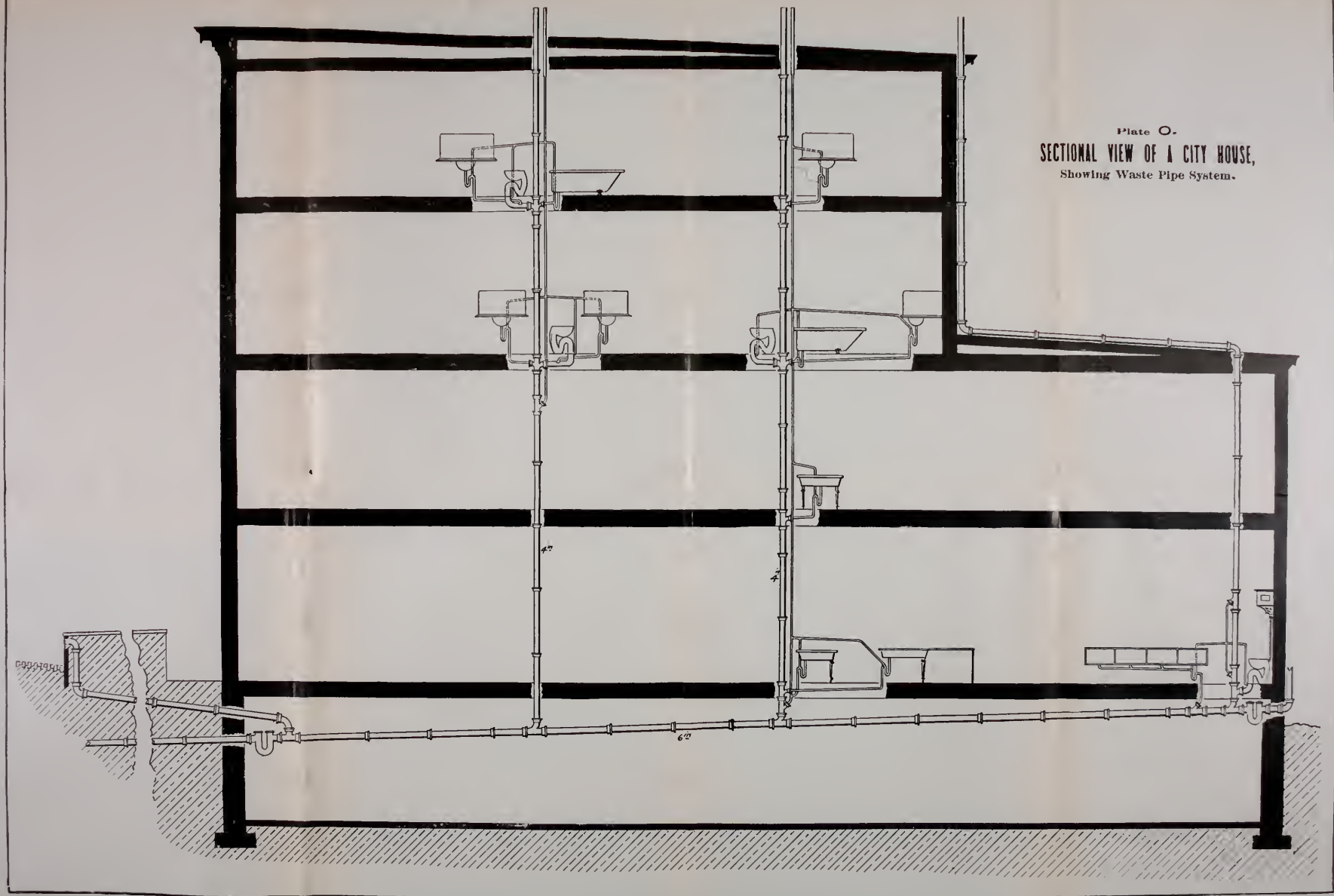
Complete Soil and Waste Pipe System of a New York City House.

In Plate O we show a complete and clear elevation of the waste pipe system as called for in New York City houses, and which may serve as a guide for the best class of plumbing in any city. In this plate is shown the soil pipe extending the entire distance of the cellar with a proper pitch of not less than one-fourth inch to one foot. The house trap is located on inside of cellar wall, with the fresh air inlet on house side of trap and extending to the street curb, as will be noticed under the sidewalk. The face of the fresh air inlet when set as shown in the curb is fitted with a brass or heavy iron screen, and placed as high as the sidewalk will permit. The main horizontal line of soil pipe is usually extended back the entire distance of the house to the rear wall, whether there may be plumbing fixtures or not at that point, and is carried to rear wall especially for the purpose of conveying the roof water to the sewer. And therefore the roof leaders are connected to the soil pipe as shown with a trap placed in soil pipe line at a point between the branch taken off for the last fixture and the rear cellar wall. This trap as shown at rear cellar wall is for the purpose of trapping the roof water leaders, and this is a proper place to locate leader traps for any style house, for the special reason that they will be protected against freezing, and will also be in a position where they can be cleaned when necessary. It is of the greatest importance in running long horizontal lines of soil pipe along the face of a wall as shown, to provide proper wrought-iron hangers or supports for same that there may be no possibility of the weight of pipe causing the line to sag. The hangers should be secured to the floor joint, which will be more safe than depending on hooks driven into the wall for supports. Where practical, there is nothing

Plate O.

SECTIONAL VIEW OF A CITY HOUSE,

Showing Waste Pipe System.



better to support such lines of heavy soil pipe than brick pillars built under the pipe at equal distances along the cellar wall. The plumber should bear in mind that when such lines of soil pipe are filled with water, there will be a considerable amount of weight to contend with, and as the joints are not as solid as the pipe proper, there will be a tendency of such lines sagging, and thereby causing the joints to leak.

In Plate O we show four fixtures situated on basement floor, two sinks, one set of laundry trays, and one water-closet; first floor, one sink; the second floor, one bath-tub, two water-closets, and three wash-basins, and on third floor, one water-closet, one bath-tub, and two wash-basins.

Size of Soil and Vent Pipes.

For a system of drainage as shown in Plate O, it is important to know the proper size of pipes. The vertical lines of soil pipe as shown are four inches diameter, and as provision is made in this system to carry off the roof water, the main horizontal line in cellar is increased to six inches diameter, otherwise a four-inch pipe for this line would be of sufficient size. The vertical lines of soil pipe are carried through the roofs without being reduced in diameter, and are left open on top without caps as shown.

Size of Back Vent Lines.

The back vent lines as shown in Plate O are two and three inches in diameter. As will be noticed, the center line, having seven fixtures to take care of, is three inches in diameter from second floor bath-room up, and increased to four inches diameter at the point of passing through the roof while this center back vent line is two inches diameter below the second floor bath-room. The back vent line from fixtures on front of house is two inches diameter all through, except at point of passing through roof, where it is increased to three inches in diameter as marked. Lateral back vent branches from traps to vertical lines are usually as follows in sizes: From ordinary kitchen sinks, one and one-half inches; laundry trays, two inches; from water-closets, two inches, and from a single wash-basin, one and one-fourth inches. A feature which I desire to call your attention to is shown in Plate O, at lower part of center vertical line of soil pipe, and this refers to the manner in which the lower connections are made with the back vent line and the soil pipe. It is advisable to carry all back air vertical lines to a point below the lowest fixture on such line, and there connect with the soil pipe, for the special reason

that condensation is constantly accumulating in these back vent lines, and by having the lower end connected to soil pipe, there will be no lodging of condensation in the pipes. And in long vertical lines of back vent pipe as shown in center of Plate O, there will be not only condensation falling down such back vent line, but a certain amount of rust scale from the interior walls of the pipe, which often lodge in sufficient quantities at the lower bend entering the soil pipe, and often completely clogging same. So that to guard against such stoppages, one fixture, such as a sink or wash basin, is allowed to drain into the lower part of back vent line, in order to wash down any accumulation of scale rust, and thus keep the opening clear at all times.

Again referring to Plate O, in reference to the plumbing fixtures situated at the rear part of house in what is called the extension, where there are two fixtures, a set of laundry tubs and one water-closet, and although these fixtures are located at a close distance from themain cellar line of soil pipe, it will be necessary to carry the four-inch line of soil pipe to a point above the upper roof of house as shown. This long line of four-inch soil pipe rising from the rear fixtures might appear like something unnecessary, but such is not the case, for the reason that, should this line end in a straight line just above the roof of the extension, there would be every possibility of air from the mouth of such pipe entering windows at the rear part of second and third floors of the house.

The line of four-inch pipe from rear fixtures in Plate O, shown exposed on roof of extension and end of main building, may be concealed if necessary under extension roof and built in rear wall of the building.

Water Pressure Regulators for Domestic and other Uses.

An uneven pressure of water for any purpose leads to great expense, through the necessity of frequent repairs, although such pressure may not be what is considered a high pressure, but where there is an extremely high pressure of water, for domestic use and applied to plumbing fixtures, there will not only be expense but a continual annoyance of various kinds throughout the house with the different plumbing fixtures, and all due to excessive pressure of the water supply. As stated in another part of this book under the head of tank supply, there is no necessity of more pressure of water in a house than that which is necessary to flow to the highest plumbing fixture in the house, and this is one reason why the indirect, or tank, supply of water for domestic use is the best system. The tank being located in the attic or

some other high point above the highest fixture, all water must come from this point, and therefore it cannot vary in pressure, and it must be remembered that, whatever the pressure of the cold water in a house may be, the hot will have exactly the same amount of pressure.

There is a supposition existing among many plumbers and men of much experience that the pressure on the hot water is less than that of the cold, and this supposition is due mainly to the fact that many times cold water will be found to run at plumbing fixtures when the hot will not run at the same fixture and same level, and where the hot water does flow at high fixtures it will be found to flow with much less force than that of the cold water.

These differences of pressure existing at times and in various locations of a building are caused by friction principally when the hot water flows with less pressure than that of the cold, and at times when the hot water will not flow under the same head as that of the cold it will be found due to air either in the boiler or some part of the hot water pipes. A special cause of much friction in the hot water system of a house will be found in the boiler, and on account of the cold water tube. Usually, where galvanized range boilers are used, no matter what may be its size, the tube placed in the boiler will be a piece of half inch galvanized pipe, the same for a twenty gallon boiler as that of a hundred gallon boiler. This is done in a large number of cases, especially on domestic housework. It will be seen that there is no consistency in such work. It practically cuts off the hot water supply for the entire building to much less than a one-half inch pipe, and all this is principally due to the use of a set of boiler couplings used on the boiler.

Tappings of Range Boilers are not Right.

As stated above, no matter what the size of the range boiler may be, the outlets are one inch, and as the best systems of range boiler setting require a tube extending down from cold water connection at top of boiler to within a few inches from bottom of boiler on the inside of same, it will be seen that this system of connecting necessitates reducing the size of tube in boiler in order to screw into the cold water boiler connection as shown in Fig. P at A. The size of this top fitting of boiler will not permit of a larger size than half-inch pipe. But this is not the only reduction we will have in the capacity of such a system of connecting galvanized range boilers with half-inch galvanized iron pipe for the tube. The average workman will be so care-

less that he will not even ream out the burs that are to be found on each end of the iron pipe tube, thus reducing the capacity again of supply to boiler.

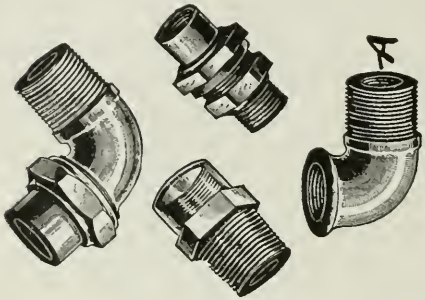


Fig. P.

It must also be remembered that we cannot get more water from a boiler than the amount we allow to flow in. The galvanized iron tube, after being in use a very short time, begins to rust, and it does not take long to again reduce its capacity from this source, so that it will be clearly seen that an iron pipe tube is not the proper kind of tube to be placed in boilers of any make, but should be of brass or copper, giving preference to the copper. Another special reason why the hot water will not flow as freely through pipes as that of the cold will be found in the fact that the warm water has a greater distance to travel before it is delivered to the fixture. The cold water connection from main line to boiler may be considered part of the pipe in which friction retards the flow of hot water, adding to this the fittings and length of boiler tube, also hot water pipe from boiler as far as the main lines to fixtures, and we will have the additional distance the hot water must travel over that of the cold supply to fixtures. There is still another good reason why hot water does not have as much pressure flowing at fixtures as that of the cold water, and which exists in many plumbing systems, and that is the connections between the waterback and boiler, and often the waterback itself, which are often found partly clogged with sediment or lime, as the case may be, according to the nature of water passing through them. These points given above should be a good guide to the practical man in determining the cause of such troubles when he may be called upon to give his opinion on such matters. It will therefore be seen that, in order to have an equal flow of hot water to that of the cold at the various fixtures the circulating tube in boiler should have a clear capacity equal to that of the cold water supply pipe for all the fixtures, and waterback connections of the same size. There are plumbers who make a practise of carrying the hot water pipe through the house one size smaller than that of the cold, and then wonder why the hot water does not run with the same

velocity as that of the cold water. Coming back to the question of water pressure and pressure regulators, the plumber should bear in mind that when there is no water being drawn through pipes of any plumbing system, the full amount of pressure due to its head, even without friction, will be exerted on all such pipes. Therefore, where we have a heavy water pressure, whatever it may be, one hundred pounds per square inch more or less, provision must be made in selecting materials to withstand such heavy pressures, and this is where a light quality of lead supply pipe would cause trouble; also light copper or iron boilers, and even certain makes of waterbacks, would be found too light for the work. Therefore, it is an important matter for the plumber in figuring on work to first find out what the water pressure is, that he may not make a mistake in selecting the quality of his material.

Fig. R.

The Curtis Regulator.

As stated on another page, the water pressure regulator should be used on plumbing supply pipes for domestic use in all cases where water is carried direct to fixtures from street main, and where such pressure is more than 30 to 40 pounds per square inch. There are many makes of water pressure regulators in the market that operate in a satisfactory manner, a few of which we here illustrate.

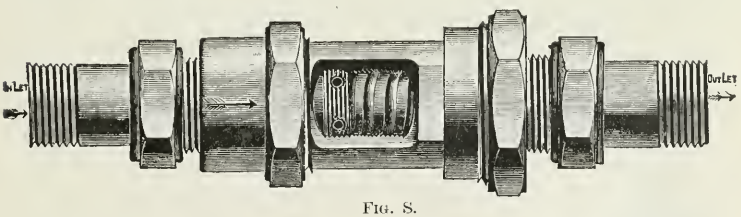


Fig. S.

The Burnett Regulator.

What a good water pressure Regulator will do, when placed on the house supply pipe under high pressure.

It will give you the desired pressure you want, if the street pressure is 90 pounds per square inch you can set your pressure regulator so that you will have 40 pounds or 30 pounds per square inch as you may require, and

once set, the pressure of water on the house side of regulator will remain the same until you desire to change it, and this may be necessary in the case of using a hose, the full pressure could be quickly turned on for that purpose, and then changed back again to the desired house pressure. It will therefore give a uniform low pressure in the house regardless of the high pressure in the street mains. It prevents bursting of pipes from excessive pressure. It prevents that disagreable hammering noise which can be heard through the entire house when faucets are being closed. The pressure regulator prevents the bursting and leaking of kitchen range boilers and waterbacks. It prevents the overflow of water-closet tanks and the unpleasant noises of a closet valve when closing off. It checks the waste of water both hot and cold, and prevents spattering of water as it is being drawn from faucets and from which much damage to floors, carpets, and furniture, also ceilings, is done.

It reduces the cost of plumbing and saves repairs, washers on faucets will last ten times as long under 40 pounds pressure as they will under 90 pounds, and this can be also said of the mechanical parts of any valve or fixture on the supply pipes of a plumbing system.

The Meuller Water Pressure Regulator.

When we come to consider the great advantages that can be had by the use of a simple water pressure regulator where cost is less than a five-dollar bill, it is surprising how a plumber of any ordinary intelligence, could not induce his customer or architect to use one such device in each house fitted with plumbing fixtures. It might be said, and true also, that such a devise was not specified, and he had to figure on the work against competition, this may be so, but any intelligent person building a house where heavy water pressure had to be contended with, could surely be made to see the advantages gained would be worth twenty times the price of Regulator, and this could be explained to the owner or architect after the contract for the plumbing may have been let. This question of regulating the pressure of water is an important matter for the architect to consider in preparing his plumbing specifications, and not only because a low water pressure saves

Mueller Water Pressure Regulator.
Fig. T.

expense and prevents damage, but because almost all kinds of plumbing fixtures operate in a more satisfactory manner under a low water pressure.

If architects and engineers who plan and specify plumbing work, would stop for a moment and consider the danger there is to the occupants of a kitchen where the range boiler is under a pressure of 100 pounds or so, and that water often above the boiling point, should a burst take place in the boiler under such conditions, the result would be much worse than the bursting of a steam boiler twenty times the size. What man would care to have his wife or children in a kitchen having a hot water boiler in operation under the conditions cited above, and strange as it may appear such important things are rarely considered by the architect of a building in specifying the plumbing work.

Laying Water Pipes in Winter.*

Water pipes have occasionally to be laid in the winter. In some localities the frost has hitherto rendered it impossible to open the ground; in others to do so is a work of time and difficulty. A means, however, has been found whereby, no matter how solidly the earth is frozen, the mains may be laid with as great ease as in summer. The agent by which this victory is gained over the frozen soil is steam, and by the new method a certain amount of ground can be opened up every day and must be finished within that time. This daily stint is laid out to a foot by the engineer, who then causes just that amount of earth to be thawed out during the night. When that has been done the excavation work follows, and the required length of main is laid before the next night comes round—and so on till the whole has been laid.

The method pursued is as follows: A set of perforated 1½ inch pipes are extended from 80 to 100 feet in two parallel lines and covered with a wooden box four inches high, the same width as the trench which is to be opened. There are several 16-foot sections of these pipes, whose joints are covered with earth and other matter, to prevent the escape of the steam—thus making the box continuous. The pipes are supplied with steam from a 12 to 15 horse-power upright boiler or steam generator. The steam is turned on with a pressure varying from 40 to 60 pounds, and is forced through the perforated pipes into the frozen ground. Only one man is required to operate the steam generator, and during the night the earth is sufficiently thawed out to the

* From Fire and Water.

required depth and ready for the excavators to work upon. This process has been found effective when the ground has been frozen hard to a depth of from three to four feet. The process can also be applied in the case of leaks when the ground is frozen to a great depth. The only requisite is haste. The main must be laid at once and the trench filled up immediately.

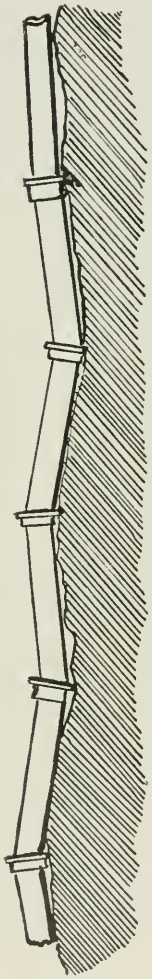


FIG. U.

How Terra Cotta or Earthen Sewer and Waste Pipes should and should not be laid.

Because a piece of work is concealed from view, is no reason why it should not be well and properly done, the very fact of pipes and some plumbing fixtures being covered by several feet of earth, and otherwise located in places not easy of access, is the best reason in the world, why such material and workmanship on same should be the very best. When the laying of terra cotta sewers, drains, and waste pipes are left entirely to the supervision of the average plumber, the work will be done in a manner similar to that shown in the illustration, Fig. U. In a long run of pipe there will scarcely be found two lengths of the pipe having the same pitch, and not only will such pipe work be found with various pitches, but it will be found laid in a zig-zag manner, and simply because the ditch was not dug to a proper line.

A Careless, Improper Way To Lay Terra Cotta Sewer Pipe.

What can be expected from a piece of pipe work constructed as shown in Fig. U ? It will not be hard to see that such a drain pipe will give trouble sooner or later by becoming clogged up with the least amount of solid matter on account of the uneven fall, the roughly fitted ends of pipe, the additional amount of friction on account of the unnecessary projections to same.

It would appear that such a line of pipe was specially constructed for the

purpose of clogging up as soon as possible after being brought into use. Yet such is not the case, but the cause for such work can be attributed to one of three things, namely, ignorance, carelessness, or dishonesty. Speaking about the laying of terra cotta sewer pipe, brings to the recollection of the writer a job of pipe work observed some years ago, which will serve to show that the plumber who laid the pipe had ideas of his own and knew how to get over obstacles. The plumber had a ditch to dig about one hundred feet long and a few feet deep for the purpose of laying a six-inch terra cotta sewer pipe, and after the ditch had been about completed a large boulder or stone was encountered, the top of which extended to a height of about three and a half inches, above the level to which the sewer had to be laid, to cut away the top of this large stone in order to secure a proper grade for the sewer would be expensive, besides it would delay completing the work, what was done to get over the obstacle can hardly be imagined, but by observing the accompanying sketch, Fig. V., the solution of the problem will be clear. This trick is not shown for

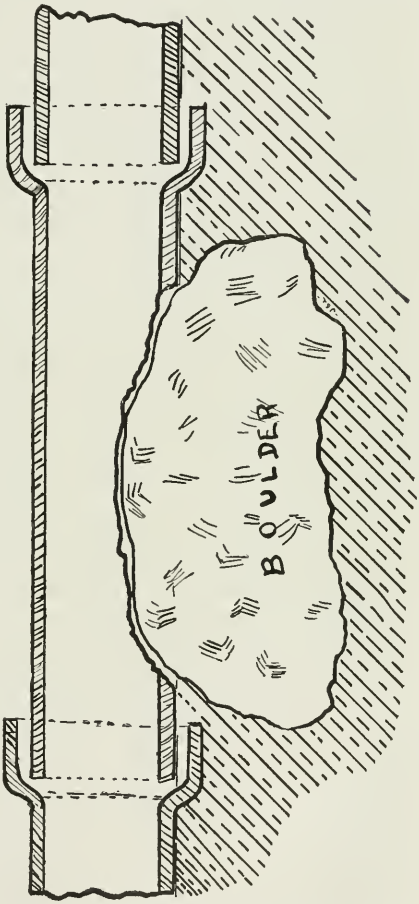


FIG. V.

the purpose of having pipe work constructed in the same manner, but to show the necessity of employing honest competent men for the construction of such important work.

As will be noticed by referring to Fig. V. about one-half was cut away from the side of a length of the sewer pipe, and fitted over the stone in the shape of a saddle, at the same time being carefully cemented all round the broken edges to the large stone and made water tight. And while this large stone reduced the capacity of the sewer at this point about one-half, it had been in use several years, and was never the cause of completely stopping the flow of water through the pipe, and was discovered on account of making changes in the waste pipe system.

There is an acknowledged correct way of doing anything, and if we are properly taught at the right time how to do plumbing work in the correct manner, it will be found just as easy and oftentimes much more simple, and taking less time, than incorrect methods of constructing such work. The laying of terra cotta sewer pipe is a most important piece of work as stated above, and not only because it is desirable to have such pipe laid to a proper uniform grade and in line, giving the least possible resistance to the flow of soil and waste water through same, but because of the nature of such pipe, it can only be properly cut, fitted and handled by men of much experience with it. The hubs of terra cotta pipe are made large enough to admit of the small end of the joint and also a packing of cement between same, therefore in laying this pipe the small ends should never rest on the bottom of the hubs in which they are placed leaving the entire space on top of hub for cement, but laid so that there will be an even amount of cement in the joint all round.

Another important point in the laying of such sewer pipe is to have a solid bearing for the body of each joint to rest on, because such pipe will stand no sagging or moving after once completed and the cement set, without breaking.

The proper way to prepare a ditch for earthen sewer pipe is to have a uniform grade the entire distance of the line if possible, and allow the pipe to rest on the natural earth, which is usually the most solid foundation, and this can be done by digging holes at each joint of the pipe as shown in Fig. W., this gives a solid bearing to the body of each joint, and at the same time, it gives the mechanic an opportunity to properly pack and cement the bottom part of each hub.

The best cement for use on terra cotta sewer pipe is that which will not set too quick, as it is best to guard against cracking of the cement to pack the pipe with earth and covering the cement at least a few inches before it is completely set; by this system there will be no chance for the pipe to be moved after the cement has once been completely set, and should the joints be disturbed a trifle in placing the earth packing around same before the cement has completely set, it will do no harm.

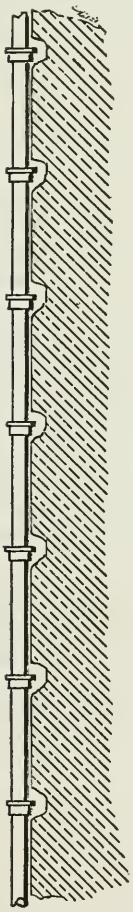


Fig. W.

As there are many chances for sewer pipe to become partly obstructed while same is being laid, by gravel, soil, and cement, it will be necessary to take precaution against such danger, and for this purpose a swab is used to draw out from the interior of the pipe any such matter that may have found its way in there. By referring to illustration, Fig. X., the method of using the sewer pipe swab will be noticed. In packing the earthen pipe hub with cement, part of the cement will find its way in through the hub and extend into the pipe beyond the end of the joints, which if allowed to remain there would become hard and obstruct the flow of water to a great extent through the pipe, but the swab being placed in the pipe as shown beyond the joint before it is cemented carries with it as it is drawn from the pipe any cement that may have passed through the hub to the inside of same, thus leaving the inside of each joint smooth and even all around. The swab is made of most

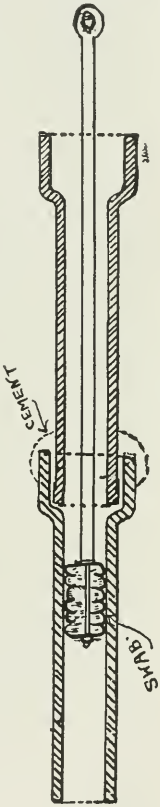


Fig. X.

any flexible material fitting the bore of the pipe in a manner similar to the plunger of a pump, and having an iron rod as the handle a little longer than the length of a joint of pipe. In placing cement around the hubs of earthen sewer pipe, it should be put on in a good heavy body as shown by the dotted lines at joint in Fig. X.

Hints to the Plumber on how to Conduct Himself, when Making Repairs in Occupied Houses.

No matter how good a mechanic a plumber may be, if he makes a poor appearance on entering a house to do some repair work, he will produce a bad impression in the minds of the persons for whom he intends to do the work.

It is true that appearance alone will not answer to construct a good piece of plumbing work, but it goes a good way in pleasing the customer by establishing confidence in him or her as the case may be, that you are intelligent and careful, and although the repairs may not be done half as well as another plumber who is in the habit of wearing dirty clothing could do it, the customer may never know the difference in the workmanship of the two plumbers cited, but will be better pleased with the man who made the best appearance There is no excuse for plumbers wearing filthy, soiled clothing when making repairs in occupied houses, and proprietors and superintendents of plumbing establishments should not tolerate such practices. It is an injury to the business, besides it is most objectionable to the customers.

There is no piece of plumbing to be done in the modernized house of to-day that will cause a man's clothes to be soiled. There is no lady of a house who does not shudder at the very thought of the plumber coming to make repairs in any part of the house above the cellar. And this is principally because she expects to find him with dirty shoes, not even wiped at the door-mat, and also with clothes smeared all over with grease and red or white lead. She is afraid that he will rub up against some wall or furniture, and who could blame her? Such filthy dressed plumbers are as a rule careless in their work. They make and leave more dirt in the house after doing a small job of repair work than would be done by a mason in plastering a room.

I have known ladies who have ordered plumbers away from the house and would not allow them to begin the work they were sent for to do, and all on account of their dirty appearance. A plumber can keep himself looking clean if he has the taste to do so. The writer, when practising the plumbing

trade, always looked clean, always wore a white collar on the street going and coming from work, always had his shoes well polished and clothing well dusted, and the customers were never afraid to allow him into the finest furnished rooms in their houses. If the mechanic is noted for being clean, neat, and careful about his appearance, it will be a good indication that his work will be of a similar character. The writer always considered that part of a plumber's outfit with his kit of tools was a good shoebrush, a whiskbroom, and a box of shoe blacking, which were carried to all jobs, and used each time as soon as repairs were finished, or when it became time to leave the house, so that clothes were never allowed to become so saturated with dust and dirt that it could not be brushed off. Careful plumbers that are properly trained, when ordered to some occupied house to make repairs, will never forget to not only see that their tools are in good shape for the work to be done, but they will see that they themselves are in good shape in regard to their appearance, and will dust off their clothes, also polish their shoes, and enter the house in a respectable-looking manner. These points are of far more importance than might be considered by the average mechanic, and my advice to young plumbers is to carry these instructions out to the letter while practising the trade, and you will find it will lead you to success and place you in the front rank of the profession.

Politeness is also a most essential quality for a plumber to have. The plumber who desires to be successful should endeavor to be polite when working in occupied houses. He should be careful what he has to say, and use only the best language that he is capable of using. He should endeavor to hide his ignorance as much as possible, and the best way to do this is to keep the mouth closed and say as little as possible. The plumber should never forget himself so far as to be heard using profane or smutty language in a customer's house. It is also a filthy practice to use tobacco in any manner while doing work in other persons' houses.

NEW YORK CITY RULES AND REGULATIONS FOR PLUMBING, DRAINAGE, WATER SUPPLY AND VENTILATION OF BUILDINGS.

I.

Filing of Drawings, Descriptions, Etc.

1. Drawings and triplicate descriptions on forms furnished by the Department of Buildings for the Boroughs of Manhattan and the Bronx, for all plumbing and drainage, shall be filled in with ink and filed by the owner, architect or plumber in the said department.

2. The said plumbing and drainage shall not be commenced or proceeded with until said drawings and descriptions shall have been so filed and approved by the Commissioner of Buildings for the boroughs of Manhattan and the Bronx.

3. No modification of the approved drawings and descriptions will be permitted unless either amended drawings and triplicate descriptions, or an amendment to the original drawings and descriptions, covering the proposed change or changes are so filed and approved by the said Commissioner of Buildings.

4. It shall not be lawful to do said plumbing and drainage except pursuant to said approved drawings and descriptions or approved amendments thereof.

5. Repairs or alterations of plumbing and drainage may be made without the filing and approval of drawings and descriptions in the Department of Buildings for the boroughs of Manhattan and the Bronx; but said repairs or alterations shall not be construed to include cases where new vertical and horizontal lines of soil, waste, vent or leader pipes are proposed to be used.

6. Notice of said repairs or alterations shall be given to the said department before the same are commenced, in all cases, except where leaks are stopped or obstructions are removed.

7. Said notice shall consist of a description in writing of the work to be done, of the location of the property where the same is executed, and of the names and addresses of the owner and of the plumber.

8. Said notice shall not, however, be required when repairs or alterations are ordered by the Board of Health, for sanitary reasons, where such repairs

or alterations do not include cases where new vertical and horizontal lines of soil, waste, vent or leader pipes are proposed to be used. In such cases, to wit, where repairs or alterations ordered by the Board of Health for sanitary reasons include cases where new vertical and horizontal lines of soil, waste, vent or leader pipes are proposed to be used or old ones replaced, drawings and descriptions must be filed with and approved by the said Commissioner of Buildings before the same shall be commenced or proceeded with.

9. All repairs and alterations shall comply in all respects with the weight, quality, arrangement and venting of the rest of the work in the building.

10. The plans must be drawn to scale in ink, on cloth, or they must be cloth prints of such scale drawings, and shall consist of such floor plans and sections as may be necessary to show clearly all plumbing work to be done, and must show partitions and method of ventilating water-closet apartments.

11. Written notice must be given to the Department of Buildings for the boroughs of Manhattan and the Bronx, by the plumber when any work is begun, and from time to time when any work is ready for inspection.

II.

Definition of Terms.

12. The term "private sewer" is applied to main sewers that are not constructed by and under the supervision of the Department of Public Works or the Department of Street Improvements of the Twenty-third and Twenty-fourth Wards.

13. The term "house sewer" is applied to that part of the main drain or sewer extending from a point two feet outside of the outer face of the outer front vault or area wall to its connection with the public sewer, private sewer or cesspool.

14. The term "house drain" is applied to that part of the main horizontal drain and its branches inside the walls of the building, and extending to and connecting with the house sewer.

15. The term "soil-pipe" is applied to any vertical line of pipe extending through roof, receiving the discharge of one or more water-closets, with or without other fixtures.

16. The term "waste-pipe" is applied to any pipe, extending through roof, receiving the discharge from any fixtures except water-closets.

17. The term "vent-pipe" is applied to any special pipe provided to ventilate the system of piping and to prevent trap syphonage and back pressure.

III.

Materials and Workmanship.

18. All materials must be of the best quality, free from defects, and all work must be executed in a thorough, workmanlike manner.

19. All cast-iron pipes and fittings must be uncoated, sound, cylindrical and smooth, free from cracks, sand-holes and other defects, and of uniform thickness and of the grade known in commerce as "extra heavy."

20. Pipe, including the hub, shall weigh not less than the following average weights per lineal foot:

Diameters.	Weights per Lineal Foot.
2 inches	5½ pounds.
3 "	9½ "
4 "	13 "
5 "	17 "
6 "	20 "
7 "	27 "
8 "	33½ "
10 "	45 "
12 "	54 "

21. The size, weight, and maker's name must be cast on each length of the pipe.

22. All joints must be made with picked oakum and molten lead and be made gas-tight. Twelve (12) ounces of fine, soft pig lead must be used at each joint for each inch in the diameter of the pipe.

23. All wrought-iron and steel pipes must be equal in quality to "standard," and must be properly tested by the manufacturer. All pipe must be lap-welded. No plain black or uncoated pipe will be permitted.

24. After January 1, 1897, wrought-iron and steel pipes must be galvanized, and each length must have the weight and maker's name stamped on it.

25. Fittings for vent-pipes on wrought-iron and steel pipes may be the ordinary cast or malleable steam and water fittings.

26. Fittings for waste or soil-pipes must be the special extra heavy cast-iron recessed and threaded drainage fittings with smooth interior water-way and threads tapped, so as to give a uniform grade to branches of no less than one-fourth of an inch per foot.

27. All joints to be screwed joints made up with red lead, and the burr formed in cutting must be carefully reamed out.

28. Short nipples on wrought-iron or steel pipe, where the unthreaded part of the pipe is less than one and one-half inches long, must be of the thickness and weight known as "extra heavy" or "extra strong."

29. The pipe shall be not less than the following average thickness and weight per lineal foot:

Diameters.	Thicknesses.	Weights per Lineal Foot.
1½ inches	.14 inches.	2.68 pounds.
2 "	.15 "	3.61 "
2½ "	.20 "	5.74 "
3 "	.21 "	7.54 "
3½ "	.22 "	9.00 "
4 "	.23 "	10.66 "
4½ "	.24 "	12.34 "
5 "	.25 "	14.50 "
6 "	.28 "	18.76 "
7 "	.30 "	23.27 "
8 "	.32 "	28.18 "
9 "	.34 "	33.70 "
10 "	.36 "	40.06 "
11 "	.37 "	45.02 "
12 "	.37 "	48.98 "

30. All brass pipe for soil, waste and vent pipes and solder nipples must be thoroughly annealed, seamless, drawn, brass tubing, of standard iron-pipe gauge.

31. Connections on brass pipe and between brass pipe and traps on iron pipe must not be made with slip joints or couplings. Threaded connections on brass pipe must be of the same size as iron pipe threads for same size of pipe and be tapered.

32. The following average thicknesses and weight per lineal foot will be required:

Diameters.	Thicknesses.	Weights per Lineal Foot.
1½ inches	.14 inches.	2.84 pounds.
2 "	.15 "	3.82 "
2½ "	.20 "	6.08 "
3 "	.21 "	7.92 "
3½ "	.22 "	9.54 "
4 "	.23 "	11.29 "
4½ "	.24 "	13.08 "
5 "	.25 "	15.37 "
6 "	.28 "	19.88 "

33. Brass ferrules must be best quality, bell-shaped, extra heavy cast brass, not less than four inches long and two and one-quarter, three and one-half inches, and four and one-half inches in diameter, and not less than the following weights:

Diameters.	Weights.
2½ inches	1 pound 0 ounces.
3½ "	1 " 12 "
4½ "	2 pounds 8 "

34. One and one-half inch ferrules are not permitted.

35. Soldering nipples must be heavy cast brass or of brass pipe, iron pipe size. When cast they must not be less than the following weights:

Diameters.	Weights.
1½ inches	0 pound 8 ounces.
2 "	0 " 14 "
2½ "	1 " 6 "
3 "	2 " 0 "
4 "	3 " 8 "

36. Brass screw caps for cleanouts must be extra heavy, not less than one eighth of an inch thick. The screw-cap must have a solid square or hexagonal nut, not less than one inch high, with a least diameter of one and one half inches. The body of the cleanout ferrule must at least equal in weight and thickness the calking ferrule for the same size of pipe.

37. Where cleanouts are required by rules and by the approved plans, the screw cap must be of brass. The engaging parts must have not less than six threads of iron pipe size and be tapered. Cleanouts must be of full size of trap up to four inches in diameter, and not less than four inches for larger traps.

38. The use of lead pipes is restricted to the short branches of the soil, waste and vent pipes, bends and traps, roof connections of inside leaders and flush pipes.

39. All lead waste, soil, vent and flush pipes must be of the best quality, known in commerce as " D," and of not less than the following weights per lineal foot:

Diameters.	Weight per Lineal Foot.
1¼ inches (for flush pipes only)	2½ pounds.
1½ "	3 "
2 "	4 "
3 "	6 "
4 and 4½ inches	8 "

40. All lead traps and bends must be of the same weights and thicknesses as their corresponding pipe-branches. Sheet lead for roof flashings must be six-pound lead and must extend not less than six inches from the pipe, and the joint made water-tight.

41. Copper tubing when used for inside leader roof connections must be seamless drawn tubing, not less than 22 gauge, and when used for roof flashings must be not less than 18 gauge.

IV.

General Regulations.

42. The entire plumbing and drainage system of every building must be entirely separate and independent of that of any other building.

43. Each building must be separately and independently connected with the public or a private sewer.

44. Every building must have its sewer connections directly in front of the building, unless permission is otherwise granted by the Commissioner of Buildings for the boroughs of Manhattan and the Bronx.

45. Where there is no sewer in the street or avenue, and it is possible to construct a private sewer to connect in an adjacent street or avenue, a private sewer must be constructed. It must be laid outside the curb, under the roadway of the street.

46. Cesspools and privy-vaults will be permitted only after it has been shown to the satisfaction of the said Commissioner of Buildings that their use is absolutely necessary.

47. When allowed, they must be constructed strictly in accordance with the terms of the permit issued by the said Commissioner of Buildings.

48. Cesspools will not be permitted under any circumstances for tenement and lodging houses, nor will they be allowed outside of the frame-building district.

49. As soon as it is possible to connect with a public sewer, the owner must have the cesspool and privy-vault emptied, cleaned and disinfected, and filled with fresh earth, and have a sewer connection made in the manner herein described.

50. All pipe-lines must be supported at the base on brick piers or by heavy iron hangers from the cellar-ceiling beams, and along the line by heavy iron hangers at intervals of not more than ten feet.

51. All pipes issuing from extension or elsewhere, which would otherwise open within thirty feet of the window of any building, must be extended above the highest roof and well away from and above all windows.

52. The arrangement of all pipes must be as straight and direct as possible. Offsets will be permitted only when unavoidable.

53. All pipes and traps should, where possible, be exposed to view. They should always be readily accessible for inspection and repairing.

54. In every building where there is a leader connected to the drain, if there are any plumbing fixtures, there must be at least one four (4) inch pipe extending above the roof for ventilation.

V.

Yard, Area and other Drains.

55. All yards, areas and courts must be drained.

56. Tenement houses and lodging houses must have their yards, areas and courts drained into the sewer.

57. These drains, when sewer-connected, must have connections not less than three inches in diameter. They should be controlled by one trap—the leader trap if possible.

58. Cellar drains will be permitted only where they can be connected to a trap with a permanent water seal.

59. Subsoil drains should discharge into a sump or receiving tank, the contents of which must be lifted and discharged into the drainage system above the cellar bottom by some approved method. Where directly sewer-connected, they must be cut off from the rest of the plumbing system by a brass flap valve on the inlet to the catch basin, and the trap on the drain from the catch basin must be water-supplied, as required for cellar drains.

VI.

Leaders.

60. All buildings shall be kept provided with proper metallic leaders for conducting water from the roofs in such manner as shall protect the walls and foundations of said buildings from injury. In no case shall the water from said leaders be allowed to flow upon the sidewalk, but the same shall be conducted by pipe or pipes to the sewer. If there be no sewer in the street upon which such buildings front, then the water from said leaders shall be conducted by proper pipe or pipes below the surface of the sidewalk to the street gutter.

61. Inside leaders must be made of cast-iron, wrought-iron or steel, with roof connections made gas and water tight by means of a heavy lead or copper-drawn tubing wiped or soldered to a brass ferrule or nipple calked or screwed into the pipe.

62. Outside leaders may be of sheet metal, but they must connect with the house drain by means of a cast-iron pipe extending vertically five feet above the grade level.

63. Leaders must be trapped with cast-iron running traps so placed as to prevent freezing.

64. Rain water leaders must not be used as soil, waste or vent pipes, nor shall any such pipe be used as a leader.

VII.

The House Sewer, House Drain, House Trap and Fresh-air Inlet.

Old house sewers can be used in connection with the new buildings or new plumbing only when they are found, on examination by the plumbing inspector, to conform in all respects to the requirements governing new sewers.

66. When a proper foundation, consisting of a natural bed of earth, rock, etc., can be obtained, the house sewer can be of earthenware pipe.

67. Where the ground is made or filled in, or where the pipes are less than three feet deep, or in any case where there is danger of settlement by frost or from any cause, and when cesspools are used, the house sewer must be of extra heavy cast-iron pipe, with lead-calked joints.

68. The house drain and its branches must be of extra heavy cast-iron, when under ground, and of extra heavy cast-iron or galvanized tarred or asphalted wrought iron or steel when above ground.

69. The house drain must properly connect with the house sewer at a point two feet outside of the outer front vault or area wall of the building. An arched or other proper opening must be provided for the drain in the wall to prevent damage by settlement.

70. If possible, the house drain must be above the cellar floor. The house drain must be supported at intervals of ten feet by eight-inch brick piers or suspended from the floor beams, or be otherwise properly supported by heavy iron-pipe hangers at intervals of not more than ten feet. The use of pipe-hooks for supporting drains is prohibited.

71. No steam-exhaust, boiler blow-off or drip-pipe shall be connected with the house drain or sewer. Such pipes must first discharge into a proper condensing tank, and from this a proper outlet to the house sewer outside of the building must be provided. In low-pressure steam systems the condensing tank may be omitted, but the waste connection must be otherwise as above required.

72. The house drain and sewer must be run as direct as possible, with a fall of at least one-quarter inch per foot, all changes in direction made with proper fittings, and all connections made with Y branches and one-eighth and one-sixteenth bends.

73. The house sewer and house drain must be at least four inches in diameter where water-closets discharge into them. Where rain-water discharges into them, the house sewer and house drain up to the leader connections must be in accordance with the following table:

Diameter.	Fall ¼-inch per Foot.	Fall ½-inch per Foot.
6 inches	5,000 square feet.	7,500 square feet of drainage of area.
7 "	6,900 "	10,300 " "
8 "	9,100 "	13,600 " "
9 "	11,600 "	17,400 " "

74. Full size Y and T branch fittings for hand-hole cleanouts must be provided when required on house drain and its branches.

75. An iron running trap must be placed on the house drain near the wall of the house, and on the sewer side of all connections, except a drip-pipe where one is used. If placed outside the house or below the cellar floor,

it must be made accessible in a brick manhole, the walls of which must be eight inches thick, with an iron or flagstone cover. When outside the house it must never be less than three feet below the surface of the ground.

The house trap must have two cleanouts with brass screw cap ferrules calked in.

76. A fresh-air inlet must be connected with the house drain just inside of the house trap, where under ground it will be of extra heavy cast-iron. Where possible it will extend to the outer air, and finish with a return bend at least one foot above grade and fifteen feet away from any window or cold-air box. When this arrangement is not possible, the fresh-air inlet must open into the side of a box not less than eighteen inches square, placed below the sidewalk at the curb. The bottom of the box must be eighteen inches below the under side of the fresh-air inlet pipe. The box may be of cast-iron, or it may be constructed with eight-inch walls of brick, or flagstone laid in hydraulic cement. The box must be covered by a flagstone fitted with removable metal grating, leaded into the stone, having openings equal in area to the area of the fresh-air inlet, and not less than one-half inch in their least dimension. The fresh-air inlet must be of the same size as the drain up to four inches; for five-inch and six-inch drains it must not be less than four inches in diameter; for seven-inch and eight-inch drains not less than six inches in diameter; and for larger drains not less than eight inches in diameter.

VIII.

Soil and Waste Pipes.

77. All main, soil, waste or vent pipes must be of iron, steel or brass.

78. When they receive the discharge of fixtures on any floor above the first they must be extended in full caliber at least one foot above the roof coping, and well away from all shafts, windows, chimneys, or other ventilating openings. When less than four inches in diameter, they must be enlarged to four inches at a point not less than one foot below the roof surface by an increases not less than nine (9) inches long.

79. No caps, cowls or bends shall be affixed to the top of such pipe.

80. In tenement houses and lodging houses wire baskets must be securely fastened into the opening of each pipe that is in an accessible position.

81. Necessary offsets above the highest fixture branch must not be made at an angle of less than 45 degrees to the horizontal.

82. Soil and waste pipes must have proper Y branches for all fixture connections.

83. Branch soil and waste pipe must have a fall of at least one-quarter inch per foot.

84. Short TY branches will be permitted on vertical lines only. Long one-quarter bends and long TY's are permitted. Short one-quarter bends and

double-hubs, short roof increasers and common offsets, and bands and saddles are prohibited.

85. The diameters of soil and waste pipes must not be less than those given in the following table:

Main soil-pipes	4 inches.
Main soil-pipes for water-closets on five or more floors	5 "
Main soil-pipes for tenement houses exceeding three stories	5 "
Branch soil-pipes	4 "
Main waste-pipes	2 "
Main waste-pipes for kitchen sinks on five or more floors	3 "
Branch waste for laundry tubs	2 "
Branch waste for kitchen sinks	2 "
Branch waste for other fixtures	1½ "

IX.

Vent-Pipes.

86. All traps must be protected from syphonage and back pressure, and the drainage system ventilated by special lines of vent-pipes.

87. All vent-pipe lines and main branches must be of iron, steel or brass. They must be increased in diameter and extended above the roof as required for waste-pipes. They may be connected with the adjoining soil or waste-line well above the highest fixture, but this will not be permitted when there are fixtures on more than six floors.

88. All offsets must be made at an angle of not less than 45° to the horizontal, and all lines must be connected at the bottom with a soil or waste pipe or the drain in such a manner as to prevent the accumulation of rust scale.

89. Branch vent-pipes should be kept above the top of all connecting fixtures, to prevent the use of vent-pipes and soil or waste pipes. They will not be permitted lower than the outlet of the highest fixture in the group. Branch vent-pipes should be connected as near to the crown of the trap as possible.

90. Earthenware traps for water-closets and slop sinks must be ventilated from the branch soil or waste pipe just below the trap, and this branch vent-pipe must be so connected as to prevent obstruction, and no waste-pipe connected between it and the fixture. Earthenware traps must have no vent-horns.

91. No sheet metal, brick or other flue shall be used as a vent-pipe.

92. The sizes of vent-pipes throughout must not be less than the following:

For main vents and long branches, two inches in diameter; for water-closets on three or more floors, and in all tenement houses exceeding three stories in height, three inches in diameter; for other fixtures on less than seven floors, two inches in diameter; three-inch vent-pipes will be permitted for less than nine stories; for more than eight and less than sixteen stories, four inches in diameter; for more than fifteen and less than twenty-two

stories, five inches in diameter; for more than twenty-one stories, six inches in diameter: branch vents for traps larger than two inches, two inches in diameter; branch vents for traps two inches or less, one and one-half inches in diameter.

For fixtures other than water-closets and slop sinks and for more than eight (8) stories, vent-pipes may be one (1) inch smaller than above stated.

X.

Traps.

93. Every fixture must be separately trapped by a water-sealing trap placed as close to the fixture outlet as possible.

94. A set of wash-trays may connect with a single trap, or into the trap of an adjoining sink, provided both sink and tub waste outlets are on the same side of the waste line, and the sink is nearest the line. When so connected the waste-pipe from the wash-trays must be branched in below the water seal.

95. The discharge from any fixture must not pass through more than one trap before reaching the house drain.

96. All traps must be well supported and set true with respect to their water levels.

97. All traps must have a water seal of at least one and one-half inches.

98. No masons, cesspool, bell, pot, bottle or D trap will be permitted, nor any form of trap that is not self-cleaning, nor that has interior chamber or mechanism, nor any trap, except earthenware ones that depend upon interior partitions for a seal.

99. All fixtures other than water-closets and urinals must have strong metallic strainers or bars over the outlets to prevent obstruction of the waste-pipe.

100. All exposed or accessible traps, except water-closet traps, must have brass trap screws for cleaning the trap placed on the inlet side, or below the water level.

101. All iron traps for house drain, yard and other drains and leaders must be running traps with hand-hole cleanouts of full size of the traps when same are less than five (5) inches. All traps underground must be made accessible by brick man-holes with proper covers.

102. Overflow pipes from fixtures must in all cases be connected on the inlet side of traps.

103. All earthenware traps must have heavy brass floor plates soldered to the lead bends and bolted to the trap flange, and the joint made gas-tight with red or white lead. The use of rubber washers for floor connections is prohibited.

104. No trap shall be placed at the foot of main soil and waste pipe lines.

105. The sizes for traps must not be less than those given in the following table:

Traps for water-closets	4	inches in diameter.
Traps for slop sinks	2	"
Traps for kitchen sinks	2	"
Traps for wash-trays	2	"
Traps for urinals	2	"
Traps for other fixtures	1½	"

XI.

Safe and Refrigerator Waste Pipes.

106. Safe and refrigerator waste pipes must be of galvanized iron, and be not less than one (1) inch in diameter, with lead branches of the same size, with strainers over the inlets secured by a bar soldered to the lead branch.

107. Safe waste-pipes must not connect directly with any part of the plumbing system.

108. Safe waste-pipes must either discharge over an open, water-supplied, publicly placed, ordinarily-used sink, placed not more than three and one-half feet above the cellar floor, or they may discharge upon the cellar floor.

109. The safe waste-pipe from a refrigerator cannot discharge upon the ground or floor. It must discharge over an ordinary portable pan, or over some properly trapped, water-supplied sink, as above.

110. The branches on vertical lines must be made by Y fittings, and be carried up to the safe with as much pitch as possible.

111. Lead safes must be graded and neatly turned over bevel strips at their edges.

112. Where there is an offset on a refrigerator waste-pipe in the cellar, there must be cleanouts to control the horizontal part of the pipe.

113. In tenement houses and lodging houses the refrigerator waste-pipes must extend above the roof, and must not be larger than one and one-half inches, nor the branches smaller than one and one-quarter inches. These branches must have full-size, accessible traps.

114. Refrigerator waste-pipes, except in tenement houses, and all safe waste-pipes must have brass flap-valves at their lower ends.

XII.

Fixtures.

115. In tenement houses, lodging houses, factories and workshops, the water-closet apartment must be made water-proof with marble, slate or tile.

In tenement houses, when the closet is used by one family only, the base must be at least six inches high. In all other cases where it is required, it must be as high as the seat.

116. In tenement houses and lodging houses the water-closet and urinal apartments must have a window opening to the outer air or to a ventilating shaft not less than 10 square feet in area.

117. In all buildings the outside partition of such apartment must extend to the ceiling or be independently ceiled over, and these partitions must be air-tight. The outside partitions must include a window opening to outer air on the lot whereon the building is situated, or some other approved means of ventilation must be provided. When necessary to properly light such apartments, the upper part of the partitions must be made of glass. The interior partitions of such apartments must be dwarfed partitions.

118. The general water-closet accommodations for a tenement or lodging house cannot be placed in the cellar.

119. No water-closet can be placed outside of a building.

120. The closets must be set open and free from all inclosing wood-work.

121. Where water-closets will not support a rim seat, the seat must be supported on galvanized iron legs, and a drip-tray must be used.

122. Every earthenware closet in all new work and in all alterations where it is not impossible to use it because of water-pipes or other obstructions, must be set on a natural stone slab. Sand or artificial stone or tile will not be allowed.

123. All water-closets must have earthenware flushing rim bowls. "Pipe-wash" bowls or hoppers will not be permitted.

124. Pan, valve, plunger, offset-washout and other water-closets having an unventilated space, or whose walls are not thoroughly washed at each discharge will not be permitted.

125. Long hoppers will not be permitted, except where there is an exposure to frost.

126. Where water-closet or other fixture traps are of iron they must be porcelain lined. Drip-trays must be enameled on both sides and secured in place.

127. In all sewer-connected occupied buildings there must be at least one water-closet, and there must be additional closets so that there will never be more than 15 persons per closet.

128. In tenement houses and lodging-houses there must be one water-closet on each floor, and when there is more than one family on a floor, there will be one additional water-closet for every two additional families.

129. In lodging-houses where there are more than 15 persons on any floor, there must be an additional water-closet on that floor for every 15 additional persons or fraction thereof.

130. Water-closets and urinals must never be connected directly with or flushed from the water-supply pipes.

131. Water-closets and urinals must be flushed from separate cisterns on each floor, the water from which is used for no other purpose.

132. The overflow of cisterns may discharge into the bowls of the closet, but in no case connect with any part of the drainage system.

133. Iron water-closet and urinal cisterns and automatic water-closet and urinal cisterns are prohibited.

134. The copper lining of water-closet and urinal cisterns must not be lighter than ten (10) ounce copper.

135. Water-closet flush-pipes must not be less than one and one-fourth inches and urinal flush-pipes one (1) inch in diameter, and if of lead must not weigh less than two and one-half pounds and two pounds per lineal foot. Flush couplings must be of full size of the pipe.

136. Latrine's trough water-closets and similar appliances may be used only on written permit from the said Commissioner of Buildings, and must be set and arranged as may be required by the terms of the permit.

137. All urinals must be constructed of materials impervious to moisture that will not corrode under the action of urine. The floor and walls of the urinal apartments must be lined with similar non-absorbent and non-corrosive material.

138. The platforms or threads of urinal stalls must never be connected independently to the plumbing system, nor can they be connected to any safe waste-pipe.

139. Iron trough water-closets and trough urinals must be enameled or galvanized.

140. In tenement houses and lodging houses sinks must be entirely open, on iron legs or brackets, without any inclosing wood-work.

141. Wooden wash-tubs are prohibited. Cement or artificial stone tubs will be permitted, provided the same be made in the following manner, to wit: To cement or artificial stone to be one part good Portland cement to not more than three parts crushed or broken granite, gneiss, or equally hard stone, broken to a size not larger than will go through a one-inch ring, well tamped; each tub to be branded with the manufacturer's name, and with the absolute mixture stamped on said tub, samples of which shall be filed and approved by this department; each compartment of the tub shall have a separate bottom outlet, with a through-and-through fitting, and overflows shall be external to the tub.

XIII.

Water Supply for Fixtures.

142. All water-closets and other plumbing fixtures must be provided with a sufficient supply of water for flushing to keep them in a proper and cleanly condition.

143. When the water pressure is not sufficient to supply freely and continuously all fixtures, a house-supply tank must be provided of sufficient size to afford an ample supply of water to all fixtures at all times. Such tanks must be supplied from the pressure or by pumps as may be necessary; when from the pressure ball-cocks must be provided.

144. If water pressure is not sufficient to fill house-tank, power-pumps must be provided for filling them in tenement houses, lodging houses, factories and workshops.

145. Tanks must be covered so as to exclude dust, and must be so located

as to prevent water contamination by gases and odors from plumbing fixtures.

146. House supply tanks must be of wood or iron or of wood lined with tinned and planished copper.

147. House tanks must be supported on iron beams.

148. The overflow pipe should discharge upon the roof where possible, and in such cases should be brought down to within six (6) inches of the roof, or it must be tapped and discharged over an open and water-supplied sink not in the same room, not over three and one-half feet above the floor. In no case shall the overflow be connected with any part of the plumbing system.

149. Emptying pipes for such tanks must be provided, and be discharged in the manner required for overflow pipes, and may be branched into overflow pipes.

150. No service pipes or supplying pipes should be run, and no tanks, flushing cisterns or water-supplied fixtures should be placed where they will be exposed to frost.

151. Where so placed they shall be properly packed, and boxed in such a manner as to prevent freezing, and to the satisfaction of the plumbing inspector.

XIV.

Testing the Plumbing System.

152. The entire plumbing and drainage system within the building must be tested by the plumber, in the presence of a plumbing inspector, under a water or air test, as directed. All pipes must remain uncovered in every part until they have successfully passed the test. The plumber must securely close all openings as directed by the Inspector of Plumbing. The use of wooden plugs for this purpose is prohibited.

153. The water test will be applied by closing the lower end of the main-house drain and filling the pipes to the highest opening above the roof with water. If the drain or any part of the system is to be tested separately, there must be a head of water at least (6) feet above all parts of the work so tested, and special provision must be made for including all joints and connections in at least one test.

154. The air test will be applied with a force-pump and mercury columns under ten pounds pressure, equal to twenty inches of mercury. The use of spring gauges is prohibited.

155. After the completion of the work, when the water has been turned on and the traps filled, the plumber must make a peppermint or smoke test in the presence of a Plumbing Inspector and as directed by him.

156. The material and labor for the tests must be furnished by the plumber. Where the peppermint test is used, two ounces of oil of peppermint must be provided for each line up to five stories and basement in height, and for each additional five stories or fraction thereof, one additional ounce of peppermint must be provided for each line.

MODERN STEAM HEATING FROM A PRACTICAL POINT OF VIEW.

Any complete work on the general utility of steam would require volumes; we will therefore confine ourselves in this part of the book to the practical utilization of steam for the warming and ventilating of buildings only.

Steam is pure water expanded by heat into an invisible vapor.

Perfect steam is in no way moist, but is as dry as are the permanent gases. It has in a complete degree those properties: fluidity, mobility, elasticity, and equality of pressure in every direction that distinguishes gases.

Saturated steam is the normal condition of steam generated in free contact with water, and same density and same pressure always exists in conjunction with same temperature. It therefore is at both its condensing and generating points, i. e. it is condensed if its temperature is reduced and more water is evaporated if its temperature is raised.

The pressure and density of steam, generated in free contact with water, rise with the temperature and reciprocally its temperature rises with the pressure and density, the higher the temperature the more rapidly the pressure advances.

There is but one and a corresponding pressure and density for each temperature. The variations in pressure and density of steam generated in free contact with water are exactly proportionate to the variations of temperature.

Under this condition steam is termed "saturated" from its containing the largest amount of water possible at any given temperature.

The pressure of steam at a boiling point of 212° is equal to the pressure of the atmosphere, which is 14.7 lbs. upon a square inch.

The expansion force of the vapor of all fluids is the same as their boiling points. A cubic inch of water evaporated under ordinary atmosphere pressure is converted into 1640 cubic inches of steam, or nearly one cubic foot and it exerts a mechanical force equal to raising 14.7 x 144=2.12 lbs. 1 ft. high.

One pound pressure of steam will support a column of mercury equal to 2.0376 inches high. The boiling point of water varies with the pressure of the atmosphere or vapor under which it is effected.

The most prominent of the properties are its high expansive force, its condensation by the obstruction of its temperature, its undeveloped heat, and the inverted ratio of its pressure to the space it occupies.

The expansive force of steam rises from the absence of cohesion between and among the particles of water.

If a known volume of steam of a certain pressure be made to occupy but one-half of its volume its elastic power will be doubled.

Steam has an expanding force always equal to the pressure under which it is generated, and its temperature theoretically is always the same as that of the water in contact with it.

Steam under ordinary atmospheric pressure 27222 cubic feet weighs one pound, and it has a gravity about equal to one-half that of air at 34°, but if the temperature of air be increased to 160°, the gravity of steam will equal two-thirds of the weight of air. This is an important point for the practical steam-fitter to bear in mind when placing air valves on steam radiators or coils of any kind for heating purposes.

What a Unit of Heat Is.

A unit of heat is that amount of heat which is required to raise the temperature of one pound of water 1° F., and is used to calculate and measure the quantity of heat.

Combustion of Fuel in House-Heating Boilers.

The combustion of fuel in any given area of grate must depend on the rapidity of the draught.

In ordinary home heating boilers, one square foot of grate will burn from 5 to 8 pounds of coal per hour.

One pound of coal should add about 9000 heat units to water in a boiler used for heating purposes.

One cubic foot of ordinary coal gas contains 650 units of heat, but 50% of this is lost in the generating of steam or heating of water by even the best construction of Bunsen or atmospheric burners, so that one cubic foot of 16-candle power gas will add about 325 units of heat to water below 200° F.

A most important thing in the construction of steam heating plants, is to properly proportion the boiler, the grate surface with the heating surface, also the proper area of chimney for a proper and economical consumption of

the fuel, and for this purpose the following diagrams have been arranged, and which are the result of practical experience and tests under various conditions.

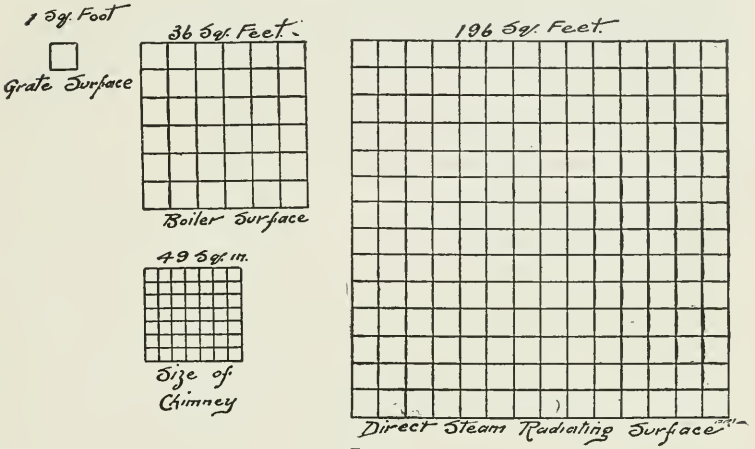


FIG. 110.

It will be noticed in referring to plate, Fig. 110, that one square foot of grate surface will supply 36 sq. ft. of boiler surface; and this amount of grate and boiler surface will carry 196 sq. ft. of direct radiating surface for heating purposes.

The area of chimney must be taken into consideration and for this amount of grate and boiler surface we allow 49 square inches.

CHIMNEY AND FLUES.

For low pressure gravity steam heating plants, carrying over 1,000 feet feet of radiation, the size of chimney may be reduced somewhat less in proportion than that shown in plate 110.

The success of any heating plant depends largely on the chimney, and no matter how well a boiler may be proportioned and constructed, there cannot be proper results unless the chimney is also properly constructed.

Chimneys intended for heating plants should never be constructed less than 8 x 8 inches in the clear even for the smallest size private house.

Brick Chimneys.

In the building of brick chimneys care should be exercised to have the joints between the bricks properly filled with the mortar, for the reason that any openings left in the joints of the brick, will interfere with the draft; this is a trouble often experienced by the author and of course is due to careless

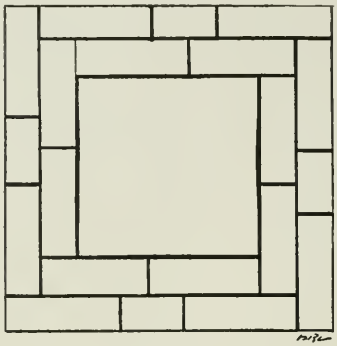


Fig. 111.

work of the mason, but which the heating engineer should give his attention for his own special benefit and the success of his heating plant. A chimney built entirely of brick should never be less than eight inches thick, as shown in Fig. 111, and the inside should be made as smooth as possible.

Chimneys Lined with Tile Flues.

Brick chimneys are often lined with terra-cotta flue lining as shown in Fig. 112, and in such cases it will not be necessary to use two thicknesses of brick as regards safety; besides this style of lining being made of fire-clay stands the heat and weather better than common brick, is more smooth, and can be built perfectly air-tight, so that the joints of the brick, even though they should leak, would not affect this draft.

Cast-iron pipe makes a good lining for brick chimneys as shown in Fig. 113, and while the area of the iron flue is less than that of the brick flue in

which it is placed, its efficiency is equal to that of the greater area of the brick flue.

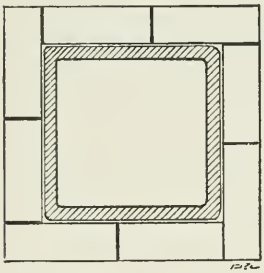


FIG. 112.

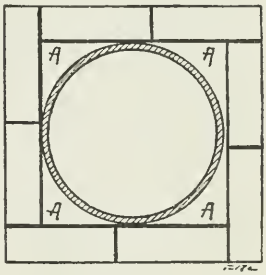


FIG. 113.

This style of chimney shown in Fig. 114, is taken advantage of and used also as VENTILATING SHAFTS.

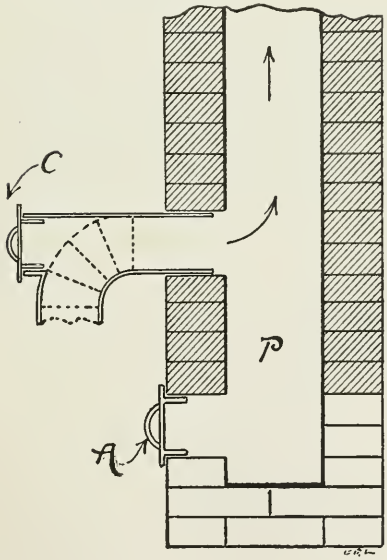


FIG. 114.

The space in the corners marked A give considerable area through which foul air from apartments of the building is caused to rise by the heat from the iron smoke flue.

In building smoke flues or chimneys for large heating plants, if entirely of brick, fire-brick should be used around the smoke pipe entrance and a few feet above on the inside as shown by the dark shading on brick in Fig. 114.

A proper receptacle or pocket should be provided at the bottom of chimney as shown at P, to hold soot and dust, provided with a clean-out door A. It is also a good plan in connecting smoke pipes to chimneys, to provide the elbow with a removable stopper as

shown at C in Fig. 114, to clean the elbow where it enters the chimney without having to remove the smoke pipe.

Height of Chimneys.

The height of a chimney is also a very important matter to consider and not altogether in regard to the number of feet it rises above the location of heater, but its position after passing through the roof in relation to the highest point of the roof.

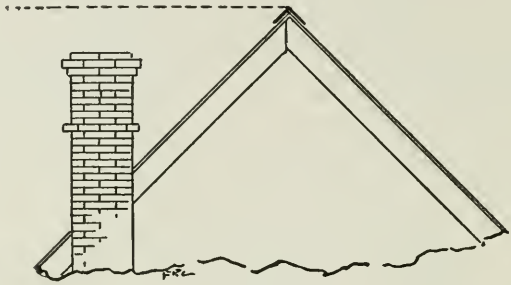


Fig. 115.

Practical experience has proved that there cannot be satisfactory results obtained from a chimney constructed as shown in Fig. 115, with its top below the peak of the roof, and therefore it is important that chimneys should ex-

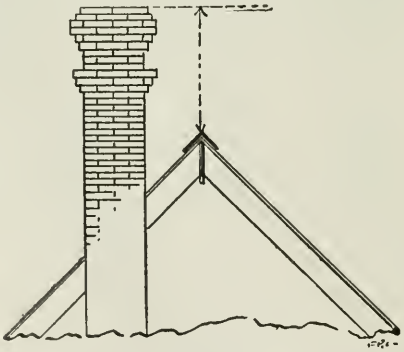


Fig. 116.

tend at least some distance above the highest part of roof as shown in sketch Fig. 116.

Heating Surface of Boilers.

In considering the question, "What is good and proper heating surface in steam boilers?" we take the horizontal tubular style of boilers as the standard, and any construction of cast or wrought iron boiler with as good heating surface may be figured in the same manner as to capacity.

Horizontal Tubular Boilers.

Diameter of Shell.	Length of Shell.	Number of Tubes.	Diameter of Tubes.	Length of Tubes.	Gauge of Shell.	Gauge of Heads.	Heating Surface.	Horse Power.
60	19	65	3½	18	5/16	½	1147	76
60	18	65	3½	17	5/16	½	1074	72
60	17	65	3½	16	5/16	½	1006	67
60	17	92	3	16	5/16	7/16	1229	82
60	16	92	3	15	5/16	7/16	1152	77
60	15	92	3	14	5/16	7/16	1075	72
60	14	92	3	13	5/16	7/16	998	67
54	19	50	3½	18	6/16	½	951	63
54	18	50	3½	17	6/16	½	900	60
54	17	50	3½	16	6/16	½	795	53
54	17	72	3	16	6/16	7/16	977	65
54	16	72	3	15	6/16	7/16	917	61
54	15	72	3	14	6/16	7/16	857	57
54	14	72	3	13	6/16	7/16	797	53
54	13	72	3	12	6/16	7/16	735	49
48	17	40	3½	16	5/16	9/16	683	46
48	17	49	3	16	6/16	9/16	684	46
48	16	49	3	15	6/16	9/16	642	43
48	15	49	3	14	6/16	9/16	600	40
48	14	49	3	13	6/16	9/16	555	37
48	13	49	3	12	6/16	9/16	513	34
48	12	65	2½	11	6/16	9/16	542	36
42	16	38	3	15	¼	9/16	508	34
42	15	38	3	14	¼	9/16	476	32
42	14	38	3	13	¼	9/16	441	30
42	13	38	3	12	¼	9/16	408	27
42	12	45	2½	11	¼	9/16	390	26
42	11	45	2½	10	¼	9/16	355	24
42	10	45	2½	9	¼	9/16	320	22
42	9	45	2½	8	¼	9/16	285	19
42	8	45	2½	7	¼	9/16	248	16
36	13	28	3	12	¼	9/16	306	20
36	12	34	2½	11	¼	9/16	298	20
36	11	34	2½	10	¼	9/16	271	18
36	10	34	2½	9	¼	9/16	244	16
36	9	34	2½	8	¼	9/16	211	14
36	8	34	2½	7	¼	9/16	190	12
30	9	30	2	8	¼	9/16	152	10
30	8	30	2	7	¼	9/16	133	8
30	7	30	2	6	¼	9/16	114	7
30	6	30	2	5	¼	9/16	95	6

In figuring up the square feet of heating surface in tubular boilers as shown in Fig. 117 we should take the area of tubes, also the two ends of boiler and one-half of the exterior sides of boiler, and although this style boiler may be set so that the products of combustion will pass three times the length of boiler which would include the upper half of outside shell, this upper part or surface could not be counted as good in rating the heating capacity of boiler. It is also a safe plan to deduct from the heating surface of a horizontal tubular boiler at least 10 per cent. for the soot and dirt which accumulates so rapidly and covers the lower part of the flues and which is allowed to remain there a good part of the time, and which is not only a good non-conductor of heat, but an obstruction to the draft in passing to the chimney.

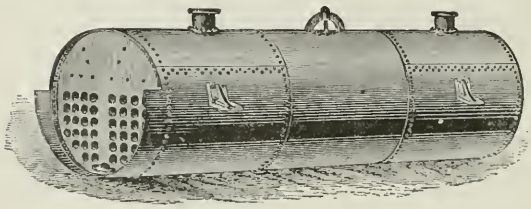


FIG. 117.

It will therefore be seen that house heating boilers which as a rule have simply the natural draft, and often very poor at that, should be frequently cleaned in order to be able to utilize the heating power of the boiler to its full capacity as well as from the standpoint of economy in the consumption of fuel.

LOW PRESSURE GRAVITY CIRCULATING SYSTEM OF STEAM HEATING.

The meaning of low pressure gravity heating, is where all condensation from the radiation returns back to the boiler by simply its own weight, so that the same water remains in the heating apparatus at all times. Rising from the boiler in the form of steam, and returning again to the lower part of boiler as water, thus keeping up a circulation through the pipe system as long as heat is required.

A steam heating plant can be constructed to return its condensation from radiation, no matter how high the pressure of steam carried in the boiler may be, and simply by gravitation alone, but such a steam heating apparatus would be too expensive for ordinary domestic purposes, and besides high pressure of steam is not desirable on account of the greater danger. Therefore the best as well as the safest system of steam heating is the lowest pres-

sure that can be carried, or in other words a steam heating system that will give the desired quality of heat without showing any pressure is without question the most perfect and such systems are quite practical. And notwithstanding the fact as stated above, that the gravity system can be used successfully at any pressure, there arises often great difficulty in the ordinary construction of low pressure steam plants when more than four or five pounds pressure of steam is carried in the boiler, and the reasons for such troubles are explained by the following illustrations Figs. 118, 119, 120, and 121 which are important for the steam-heating engineer to bear in mind when laying out his work.

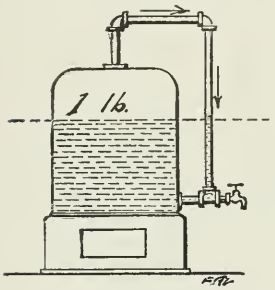


Fig. 118.

In Fig. 118 we show a steam boiler having a loop formed by a simple piece of pipe rising from top of boiler and connecting to side of boiler near bottom with the water line shown in both boiler and pipe on side. This might be called a complete steam heating apparatus in itself and the loop or pipe above the water line is the radiating surface while circulation moves in the direction of the arrows. In this little system it will be noticed that the water level stands about the same height in return pipe as it stands in boiler, and the reason of this is the pipe being so short or the radiating surface small and close to the boiler so that the pressure of steam in the loop above the water line, is the same as it is above the boiler.

We now extend the loop some distance farther away from boiler, as shown in Fig. 119, and while we carry the same pressure of steam, one pound, in both boilers, Figs. 118 and 119, there will be a difference in the height of water line as shown at A in Fig. 119, and this is because there is a difference in steam pressure between the water level in boiler and that of the water level in return pipe at A. Then again the reason of this loss or difference in pressure is

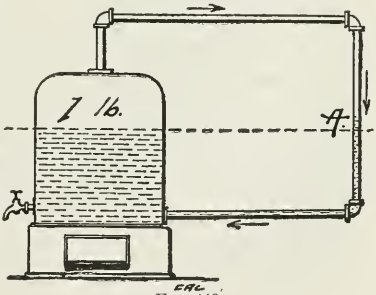


Fig. 119.

due to loss of heat which has taken place in the supply pipe or radiating surface between the boiler and return pipe.

An important thing to bear in mind in considering these points, is that water, practically being incompressible, will have the same pressure on it at any point from the boiler as that which is exerted on the surface of the water in the boiler by the steam. But this is not the case with steam in a heating apparatus, because steam loses its power as it condenses and consequently the more distant from the boiler the less will be the pressure of steam in the supply or main pipe.

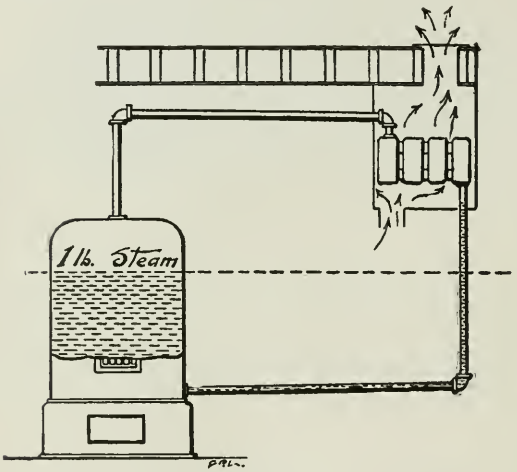


FIG. 120.

In locating indirect stacks of steam radiation, especially at great distances from the boiler, trouble from difference in pressure of steam will be experienced unless the pipework is properly constructed and a low pressure of steam carried. It is quite possible to have one pound pressure of steam shown at the boiler and no indicated pressure in the indirect nest, Fig. 120, and the result would be, that water would stand in the return connection from indirect nest at a point about two feet higher than the level of water line in boiler.

It will therefore be seen that under unfavorable conditions, it would be quite possible to even have the return water stand in the indirect stack thereby preventing the apparatus from heating.

Still another illustration showing how there may be trouble from uneven steam pressure is shown in Fig. 121, and this refers especially to plants where most all the radiation is located in close proximity to the boilers, and a small amount of surface located at a great distance from boiler. In such cases five

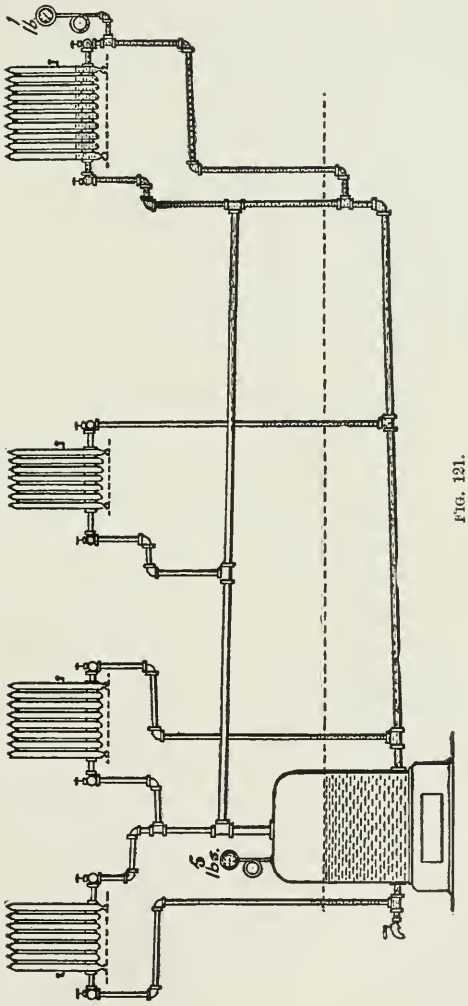


FIG. 121.

pounds pressure of steam may be carried at the boiler, while only one pound would indicate at the distant radiator, and bearing in mind the fact that the five pounds pressure at the boiler exerted on the water, holds good to any distance in the return pipe without the slightest loss, it will be seen that there is four pounds pressure per square inch difference between that or the return pipe and steam in supply at end of the more distant radiator, and consequently there can be no other result than the backing up of return water into both flow pipe and radiator as indicated in illustration, Fig. 121. The lesson we learn from the above is that in constructing low pressure gravity steam heating plants, they must be so constructed as to properly warm the cubical contents of the building in which such plant may be installed with the least possible pressure of steam carried at the boiler, and it would be better still to heat with simply vapor without any indicated pressure on the boiler.

Large Flow Pipes are Necessary.

Perhaps one of the most difficult problems connected with low pressure steam heating plants is, to deliver a uniform supply of steam to the radiating surfaces as located in various situations throughout the building to be warmed, and it may also be said to accomplish this important feature in the steam plant, the most necessary thing to be sure of is to have the supply pipes which convey steam to the radiation of good size, and at the same time well protected from the cooling effects of the atmosphere surrounding same. Before going on with the work of construction, there are a few points in regard to water lines of boilers I desire to speak about, as such information will be of value to the heating engineer as he progresses farther in this work.

Uneven Water Lines in Steam Boilers.

A source of great annoyance in about 50 per cent. of the steam heating apparatus is the uncertainty of the water line in the boiler, and there are a number of good reasons for this, but all of which are avoided by heating engineers of experience.

In low pressure gravity steam heating plants, there is practically no waste of water, as the water first placed in the boiler is used constantly, passing from the boiler as stated above in the form of steam and returning again to the bottom of boiler as water without loss; yet at times under various conditions the water leaves the boiler, to a great extent endangering at least the

crown sheet and often all parts from being burned. Where steam boilers are found acting in this manner it is an indication that something is wrong in the system, and while such troubles can often be traced to imperfect pipe work or improper handling of radiator valves, they can also be traced at times to the imperfect construction of the boiler.

Boilers are frequently placed on the market without having had practical tests to prove scarcely anything about them, and very often by persons who have not had the proper training or sufficient practical experience to prove them competent to design boilers for such important work, and the consequence is, that in many such cases the fitter, as well as the unfortunate occupant of the house in which such boiler may be installed, is made to suffer.

A construction of boiler that will not hold a practically steady water line will not be allowed for power purposes, although it may make sufficient steam for the purpose it is intended. The reason of this is that it is not safe and cannot be depended upon, with water fluctuating in a steam boiler no person can tell how much water is in such boiler at the time. There is good reason to believe that boilers used for house heating that will not hold a steady water line should not be allowed by law, even from the standpoint of safety. But there is another point connected with boilers of this class, which is extravagance in the consumption of fuel. Any boiler that fluctuates wastes fuel, besides endangering parts by suddenly becoming dry and as quickly flooding.

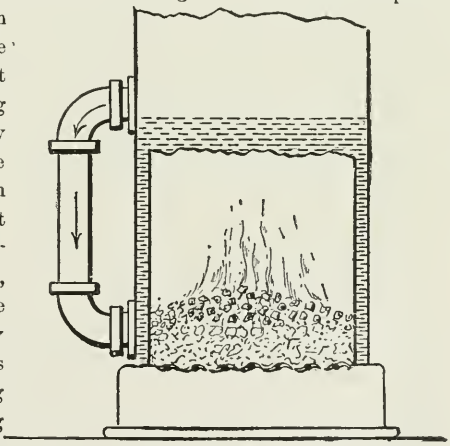


FIG. 122.

Such boilers of cast iron frequently crack and cause expensive repairs necessary, even when running under low pressure from one to five pounds. If such a boiler is of wrought iron tubular pattern, the fluctuation of the water will often cause the bottom of the tubes to leak, and the crown sheet in such cases will not be of long life.

A plan which in a measure gives more steadiness to the water line in imperfectly constructed boilers, is shown in the accompanying illustration, Fig. 122. This consists of a pipe of large size, connected, as shown on the right, to the upper and lower part of the boiler, with the upper nipple entering the boiler about even with the desired water line, while the lower nipple enters the boiler at a point near the bottom. This arrangement of pipe on the side or back of the boiler, which is called a relief or equalizing pipe, carries back the water which has been forced up through the interior of the boiler by the heat. This is due to the fact that in such boilers there is not proper provision for local circulation, and in the boiler proper the water can only rise. Therefore, as a sort of a makeshift, the pipe is added to the boiler to return this water. A steam boiler of proper construction should be provided with sufficient water space for a good local circulation.

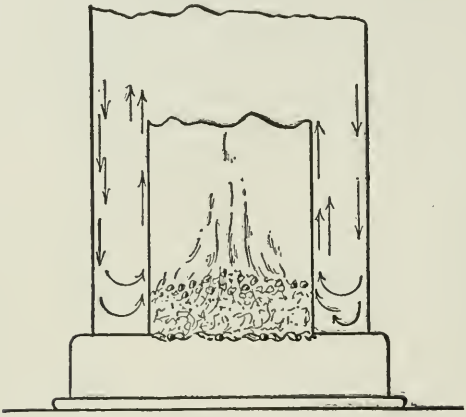


FIG. 123.

Referring to the accompanying illustration, Fig. 123, the sides being much thicker than are shown in Fig. 122, gives the proper meaning of the point in question. As will be noticed, the direction of the arrows in Fig. 123 show how the water circulates in a steam boiler when it has a sufficient body of water. This question brings to mind the fact that there can be too much fire space in steam boilers, and that there must be proper water space as well as fire space. When water is lifted, as it is called, in a steam boiler, and thrown into the steam chamber by excessive heat, or the lack of proper local circulation, there will be less steam generated at such times than when there is a good local circulation.

It often happens that the same make of boiler will hold a steady water line in one plant, and in another setting will show a very poor water line. And in such cases it will be found that a forced or strong draft with a heavy

fire will be the cause of this trouble. While with a slow or comparatively poor draft this may never be noticed in the boiler. In such cases the best remedy would be to check the draft in the chimney. Therefore, under such circumstances, this class of boiler cannot be forced to any great extent. There is no use or benefit in forcing the draft in boilers so that they will lift the water and retard local circulation, because, just as soon as this circulation is in any measure stopped, just at that time the fire heating surface in the boiler ceases to do its full quantity of work, and less steam will be generated, besides the steam outlets from the boiler will be obstructed by water.

Water in gravity return systems is sometimes prevented from returning to the boiler even after the pressure of steam has dropped below atmospheric pressure at the boiler, and this will be found in the fact that some of the radiation has retained a quantity of the condensation, on account of not having an automatic supply of air from the exterior atmosphere, or in other words, because some of the radiators are not provided with good automatic air valves, and the water will not pass out of radiator and return to boiler until air is allowed to pass into such radiator to fill the partial vacuum formed there, or until steam is forced into the radiator which will cause the water to fall back into return pipes.

This proves the great necessity of providing all radiators with good automatic air valves, not only for the purpose of allowing all condensation to pass quickly to the boiler, but to allow the radiators to warm up as quickly again when steam is generated.

Trouble from Improper Turning of Steam Radiator Valves.

Still another source of trouble and loss of water from the boiler comes in the manner in which radiator valves are handled, especially on the two pipe systems, and this is when it is desirable to close off the heat; the inlet valve is closed, while the return valve may be left partly or entirely open, thus allowing condensation to back up from some other source and thus storing up a considerable amount of water in the radiator, to the detriment of the boiler, because this water is not intended to accumulate in any part of the system above the return pipes but fall by gravitation to the boiler.

It will therefore be seen that on two pipe radiators, both valves must be left wide open or both perfectly closed, in order to have the apparatus operate in a proper manner.

OUTSIDE DIAMETER OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE. FROM ONE-EIGHTH TO TEN INCHES.

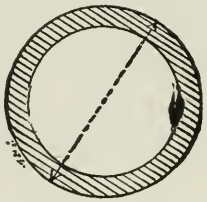


FIG. 124.

Size of pipe	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Outside diameter of pipe	$\frac{40}{100}$	$\frac{54}{100}$	$\frac{67}{100}$	$\frac{84}{100}$	$1\frac{05}{100}$
Size of pipe	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Outside diameter of pipe	$1\frac{31}{100}$	$1\frac{66}{100}$	$1\frac{90}{100}$	$2\frac{37}{100}$	$2\frac{87}{100}$
Size of pipe	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Outside diameter of pipe	$3\frac{50}{100}$	$4\frac{00}{100}$	$4\frac{50}{100}$	$5\frac{00}{100}$	$5\frac{56}{100}$
Size of pipe	6	7	8	9	10
Outside diameter of pipe	$6\frac{62}{100}$	$7\frac{62}{100}$	$8\frac{62}{100}$	$9\frac{62}{100}$	$10\frac{77}{100}$

THICKNESS OF STANDARD WROUGHT-IRON, STEAM, GAS AND WATER PIPE. FROM ONE-EIGHTH TO TEN INCHES.

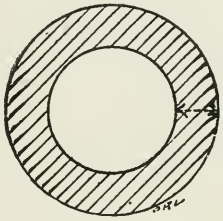


FIG. 125.

Size of pipe	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Thickness of pipe	$\frac{68}{1000}$	$\frac{88}{1000}$	$\frac{91}{1000}$	$\frac{109}{1000}$	$\frac{113}{1000}$
Size of pipe	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Thickness of pipe	$\frac{134}{1000}$	$\frac{140}{1000}$	$\frac{145}{1000}$	$\frac{154}{1000}$	$\frac{204}{1000}$
Size of pipe	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Thickness of pipe	$\frac{217}{1000}$	$\frac{226}{1000}$	$\frac{237}{1000}$	$\frac{247}{1000}$	$\frac{259}{1000}$
Size of pipe	6	7	8	9	10
Thickness of pipe	$\frac{280}{1000}$	$\frac{301}{1000}$	$\frac{322}{1000}$	$\frac{343}{1000}$	$\frac{366}{1000}$

INSIDE CIRCUMFERENCE OF STANDARD WROUGHT IRON STEAM, GAS AND WATER PIPE. FROM ONE-HALF TO TEN INCHES.

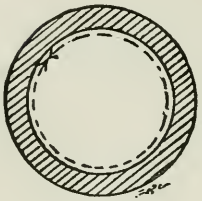


FIG. 126.

Size of pipe in inches	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Inside circumference of pipe in inches	$\frac{864}{1000}$	$1\frac{44}{1000}$	$1\frac{552}{1000}$	$1\frac{957}{1000}$	$2\frac{509}{1000}$
Size of pipe in inches	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Inside circumference of pipe in inches	$3\frac{292}{1000}$	$4\frac{385}{1000}$	$5\frac{61}{1000}$	$6\frac{494}{1000}$	$7\frac{754}{1000}$
Size of pipe in inches	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Inside circumference of pipe in inches	$9\frac{686}{1000}$	$11\frac{136}{1000}$	$12\frac{648}{1000}$	$14\frac{263}{1000}$	$15\frac{849}{1000}$
Size of pipe in inches	6	7	8	9	10
Inside circumference of pipe in inches	$19\frac{54}{1000}$	$22\frac{68}{1000}$	$25\frac{76}{1000}$	$28\frac{277}{1000}$	$32\frac{475}{1000}$

OUTSIDE CIRCUMFERENCE OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE FROM ONE-EIGHTH TO TEN INCHES.

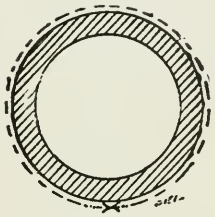


FIG. 127.

Size of pipe in inches	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Outside circumference	$1\frac{272}{1000}$	$1\frac{696}{1000}$	$2\frac{221}{1000}$	$2\frac{652}{1000}$	$3\frac{299}{1000}$
Size of pipe in inches	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Outside circumference	$4\frac{234}{1000}$	$5\frac{295}{1000}$	$5\frac{889}{1000}$	$7\frac{461}{1000}$	$9\frac{32}{1000}$
Size of pipe in inches	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Outside circumference	$10\frac{996}{1000}$	$12\frac{566}{1000}$	$14\frac{237}{1000}$	$15\frac{708}{1000}$	$17\frac{475}{1000}$
Size of pipe in inches	6	7	8	9	10
Outside circumference	$20\frac{813}{1000}$	$23\frac{954}{1000}$	$27\frac{96}{1000}$	$30\frac{433}{1000}$	$33\frac{772}{1000}$

LENGTH OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE CONTAINING ONE SQUARE FOOT OF OUTSIDE SURFACE, FROM ONE-EIGHTH TO TEN INCHES.

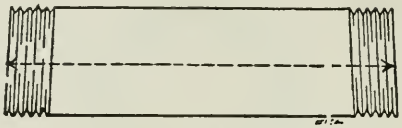


FIG. 128.

Size of pipe	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{4}$
Feet of pipe containing one square foot of outside surface	$9\frac{440}{1000}$	$7\frac{76}{1000}$	$5\frac{657}{1000}$	$4\frac{838}{1000}$	$3\frac{697}{1000}$
Size of pipe	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Feet of pipe containing one square foot of outside surface	$2\frac{905}{1000}$	$2\frac{805}{1000}$	$2\frac{00}{1000}$	$1\frac{602}{1000}$	$1\frac{308}{1000}$
Size of pipe	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Feet of pipe containing one square foot of outside surface	$1\frac{91}{1000}$	$\frac{955}{1000}$	$\frac{849}{1000}$	$\frac{766}{1000}$	$\frac{629}{1000}$
Size of pipe	6	7	8	9	10
Feet of pipe containing one square foot of outside surface	$\frac{677}{1000}$	$\frac{595}{1000}$	$\frac{444}{1000}$	$\frac{394}{1000}$	$\frac{355}{1000}$

LENGTH OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE THAT WILL HOLD ONE CUBIC FOOT OF WATER. FROM ONE-EIGHTH TO TEN INCHES.

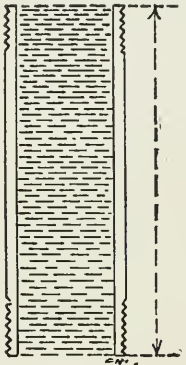


FIG. 129.

Size of pipe	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Feet of pipe containing one cubic foot of water	2500	1385	$751\frac{40}{100}$	$472\frac{40}{100}$	270
Size of pipe	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Feet of pipe containing one cubic foot of water	$166\frac{60}{100}$	$96\frac{25}{100}$	$70\frac{65}{100}$	$42\frac{36}{100}$	$30\frac{11}{100}$
Size of pipe	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Feet of pipe containing one cubic foot of water	$19\frac{49}{100}$	$14\frac{56}{100}$	$11\frac{31}{100}$	$9\frac{3}{100}$	$7\frac{20}{100}$
Size of pipe	6	7	8	9	10
Feet of pipe containing one cubic foot of water	$4\frac{98}{100}$	$3\frac{72}{100}$	$2\frac{88}{100}$	$2\frac{26}{100}$	$1\frac{80}{100}$

WEIGHT OF WATER IN POUNDS, CONTAINED IN ONE FOOT OF STANDARD WROUGHT-IRON STEAM, GAS, AND WATER PIPE. FROM THREE-FOURTHS TO SIXTEEN INCHES.

Size of pipe		$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2
Weight of water in one foot in length		$\frac{26}{100}$	$\frac{37}{100}$	$\frac{64}{100}$	$\frac{89}{100}$	$1\frac{45}{100}$
Size of pipe		$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$
Weight of water in one foot in length		$2\frac{7}{100}$	$3\frac{20}{100}$	$4\frac{28}{100}$	$5\frac{60}{100}$	$6\frac{28}{100}$
Size of pipe	5	6	7	8	9	10
Weight of water in one foot in length	$8\frac{68}{100}$	$12\frac{25}{100}$	$16\frac{87}{100}$	$21\frac{61}{100}$	$27\frac{26}{100}$	$34\frac{60}{100}$
Size of pipe	11	12	13	14	15	16
Weight of water in one foot in length	$41\frac{60}{100}$	49	$59\frac{55}{100}$	$68\frac{28}{100}$	$82\frac{20}{100}$	$91\frac{70}{100}$

WEIGHT PER FOOT IN LENGTH OF STANDARD SIZE WROUGHT IRON STEAM GAS, AND WATER PIPE FROM ONE-EIGHTH TO TEN INCHES.

Size of pipe	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Weight per foot in length in lbs.	$\frac{245}{1000}$	$\frac{425}{1000}$	$\frac{661}{1000}$	$\frac{845}{1000}$	$1\frac{1.85}{1000}$
Size of pipe	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Weight per foot in length in lbs.	$1\frac{679}{1000}$	$2\frac{258}{1000}$	$2\frac{694}{1000}$	$3\frac{667}{1000}$	$5\frac{775}{1000}$
Size of pipe	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Weight per foot in length in lbs.	$7\frac{647}{1000}$	$9\frac{66}{1000}$	$10\frac{785}{1000}$	$12\frac{493}{1000}$	$14\frac{564}{1000}$
Size of pipe	6	7	8	9	10
Weight per foot in length in lbs.	$18\frac{767}{1000}$	$23\frac{410}{1000}$	$28\frac{348}{1000}$	$34\frac{677}{1000}$	$40\frac{641}{1000}$

NUMBER OF THREADS TO THE INCH OF SCREW ON AMERICAN STANDARD WROUGHT-IRON, STEAM, GAS AND WATER PIPE, FROM ONE-EIGHTH TO TEN INCHES.

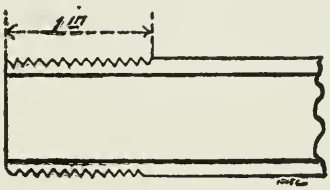


FIG. 130.

Size of pipe	⅛	¼	⅜	½	¾
Number of threads per inch	27	18	18	14	14
Size of pipe	1	1¼	1½	2	2½
Number of threads per inch	11½	11½	11½	11½	8
Size of pipe	3	3½	4	4½	5
Number of threads per inch	8	8	8	8	8
Size of pipe	6	7	8	9	10
Number of threads per inch	8	8	8	8	8

TABLE OF DIMENSIONS OF EXTRA STRONG WROUGHT-IRON PIPE.

Nominal Inside Diameter.	Actual Inside Diameter	Actual Outside Diameter	Thickness.	Inside Circumference.	Outside Circumference.	Length of Pipe per Square Foot of Inside Surface.	Length of Pipe per Square Foot of Outside Surface.	Inside Area.	Outside Area.	Nominal Weight per Foot
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Feet.	Feet.	Sq-Inches	Sq-In's.	Pounds.
⅛	.20	.40	.10	.64	1.27	18.63	9.43	.03	.12	.29
¼	.29	.54	.12	.92	1.69	12.98	7.07	.06	.22	.54
⅜	.42	.67	.12	1.32	2.12	9.07	5.65	.13	.35	.74
½	.54	.84	.14	1.70	2.63	7.04	4.54	.23	.55	1.09
¾	.73	1.05	.15	2.31	3.29	5.10	3.63	.45	.86	1.53
1	.95	1.31	.18	2.98	4.13	4.01	2.90	.71	1.35	2.17
1¼	1.27	1.66	.19	3.99	5.21	3.00	2.30	1.27	2.16	3.00
1½	1.49	1.90	.20	4.69	5.96	2.55	2.01	1.75	2.83	3.63
2	1 93	2.37	.22	6.07	7.46	1.97	1.60	2.93	4.43	5.02
2½	2.31	2.87	.28	7.27	9.03	1.64	1.32	4.20	6.49	7.67
3	2.89	3.50	.30	9.08	10.99	1.32	1.00	6.56	9.62	10.25
3½	3.35	4.00	.32	10.54	12.56	1 13	.95	8.85	12.56	12.47
4	3.81	4.50	.34	11.99	14.13	1.00	.84	11.44	15.90	14.97
4½	4.25	5.00	.35	13.35	15.71	.90	.76	14.18	19.63	17.60
5	4.81	5.56	.37	15.12	17.47	.79	.68	18.19	24.30	20.54
6	5.75	6.62	.43	18.06	20.81	.66	.57	25.93	34.47	28.58
7	6.62	7.62	.50	20.81	23.56	.58	.50	34.47	45.66	37.60
8	7.50	8.62	.56	23.95	27.10	.51	.44	44.18	58.42	47.85

Extra strong and double extra strong pipe is always shipped without Threads or Couplings, unless otherwise specified.

Threads and Couplings on extra strong pipe are always charged extra. Quotations will not cover them unless they are clearly specified in requests for prices.

TABLE OF DIMENSIONS OF DOUBLE EXTRA STRONG WROUGHT-IRON PIPE.

Nominal Inside Diam.	Actual Inside Diam.	Actual Outside Diam.	Thickness.	Inside Circumference.	Outside Circumference.	Length of Pipe per Square Foot of Inside Surface.	Length of Pipe per Square Foot of Outside Surface.	Inside Area.	Outside Area.	Nominal Weight per Foot
⅜	.23	.67	.22	.73	2.12	15.69	5.65	.04	.36	.96
½	.24	.84	.29	.76	2.63	15.66	4.54	.04	.55	1.50
⅜	.42	1.05	.31	1.32	3.29	9.04	3.63	.13	.86	2.30
1	.58	1.31	.36	1.84	4.13	6.50	2.90	.27	1.35	3.40
1¼	.88	1.66	.38	2.78	5.21	4.31	2.30	.61	2.16	5.00
1½	1.08	1.90	.40	3.41	5.96	3.51	2.01	.93	2.83	6.45
2	1.49	2.37	.44	4.68	7.46	2.56	1.60	1.74	4.43	9.00
2½	1.75	2.87	.56	5.51	9.03	2.17	1.32	2.41	6.49	13.30
3	2.28	3.50	.60	7.17	10.99	1.67	1.09	4.09	9.62	18.50
3½	2.71	4.00	.64	8.53	12.56	1.40	.95	5.79	12.56	22.00
4	3.13	4.50	.68	9.85	14.13	1.21	.84	7.72	15.90	27.48
4½	3.56	5.00	.72	11.20	15.71	1.05	.76	9.96	19.64	32.45
5	4.06	5.56	.75	12.76	17.47	.94	.68	12.69	24.30	38.12
6	4.87	6.62	.78	15.89	20.81	.78	.57	20.10	34.47	53.11
7	5.98	7.62	.82	18.83	23.95	.62	.50	28.16	45.66	60.34
8	6.88	8.62	.87	21.61	27.10	.56	.44	37.17	58.43	71.52

EQUATION OF PIPES.

It is frequently desired to know what number of pipes of a given size are equal in carrying capacity to one pipe of a larger size. At the same velocity of flow the volume delivered by two pipes of different sizes is proportional to the squares of their diameters; thus, one 4-inch pipe will deliver the same volume as four 2-inch pipes. With the same head, however, the velocity is less in the smaller pipe, and the volume delivered varies about as the square root of the fifth power (*i. e.* as the 2.5 power). The following table has been calculated on this basis. The figures opposite the intersection of any two sizes is the number of the smaller-sized pipes required to equal one of the larger. Thus, one 4-inch pipe is equal to 5.7 2-inch pipes.

Diameter, Inches.	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	24
2	5.7	1														
3	15.6	2.8	1													
4	32	5.7	2.1	1												
5	55.9	9.9	3.6	1.7	1											
6	88.2	15.6	5.7	2.8	1.6	1										
7	130	22.9	8.3	4.1	2.3	1.5	1									
8	181	32	11.7	5.7	3.2	2.1	1.4	1								
9	243	43	15.6	7.6	4.3	2.8	1.9	1.3	1							
10	316	55.9	20.3	9.9	5.7	3.6	2.4	1.7	1.3	1						
11	401	70.9	25.7	12.5	7.2	4.6	3.1	2.2	1.7	1.3						
12	499	88.2	32	15.6	8.9	5.7	3.8	2.8	2.1	1.6	1					
13	609	108	39.1	19	10.9	7.1	4.7	3.4	2.5	1.9	1.2					
14	733	130	47	22.9	13.1	8.3	5.7	4.1	3.0	2.3	1.5	1				
15	787	154	55.9	27.2	15.6	9.9	6.7	4.8	3.6	2.8	1.7	1.2				
16	. ...	181	65.7	32	18.3	11.7	7.9	5.7	4.2	3.2	2.1	1.4	1			
17	.....	211	76.4	37.2	21.3	13.5	9.2	6.6	4.9	3.8	2.4	1.6	1.2			
18	.....	243	88.2	43	24.6	15.6	10.6	7.6	5.7	4.3	2.8	1.9	1.3	1		
19	....	278	101	49.1	28.1	15.7	12.1	8.7	6.5	5	3.2	2.1	1.5	1.1		
20	.....	316	115	55.9	32	20.3	13.8	9.9	7.4	5.7	3.6	2.4	1.7	1.3	1	
22	... .	401	146	70.9	40.6	25.7	17.5	12.5	9.3	7.2	4.6	3.1	2.2	1.7	1.3	
24	.....	499	181	88.2	50.5	32	21.8	15.6	11.6	8.9	5.7	3.8	2.8	2.1	1.6	1
26	.....	609	221	108	61.7	39.1	26.6	19	14.2	10.9	7.1	4.7	3.4	2.5	1.9	1.2
28	.....	733	266	130	74.2	47	32	22.9	17.1	13.1	8.3	5.7	4.1	3	2.3	1.5
30	. ...	787	316	154	88.2	55.9	38	27.2	20.3	15.6	9.9	6.7	4.8	3.6	2.8	1.7
36	.....	.....	499	243	130	8.82	60	43.	32	24.6	15.6	10.6	7.6	5.7	4.3	2.8
42	.....	.....	733	357	205	130	88.2	63.2	47	36.2	19	15.6	11.2	8.3	6.4	4.1
48	.....	.....	.....	499	286	181	123	88.2	62.7	50.5	32	21.8	15.6	11.6	8.9	5.7
54	.....	....	.....	670	383	243	165	118	88.2	67.8	43	29.2	20.9	15.6	12	7.6
60	.....	....	....	787	499	316	215	154	115	88.2	55.9	38	27.2	20.3	15.6	9.9

A Complete Low Pressure Steam Heating Boiler.

For the purpose of familiarizing the reader with the various trimmings required in a complete steam heating boiler, and also to explain the special

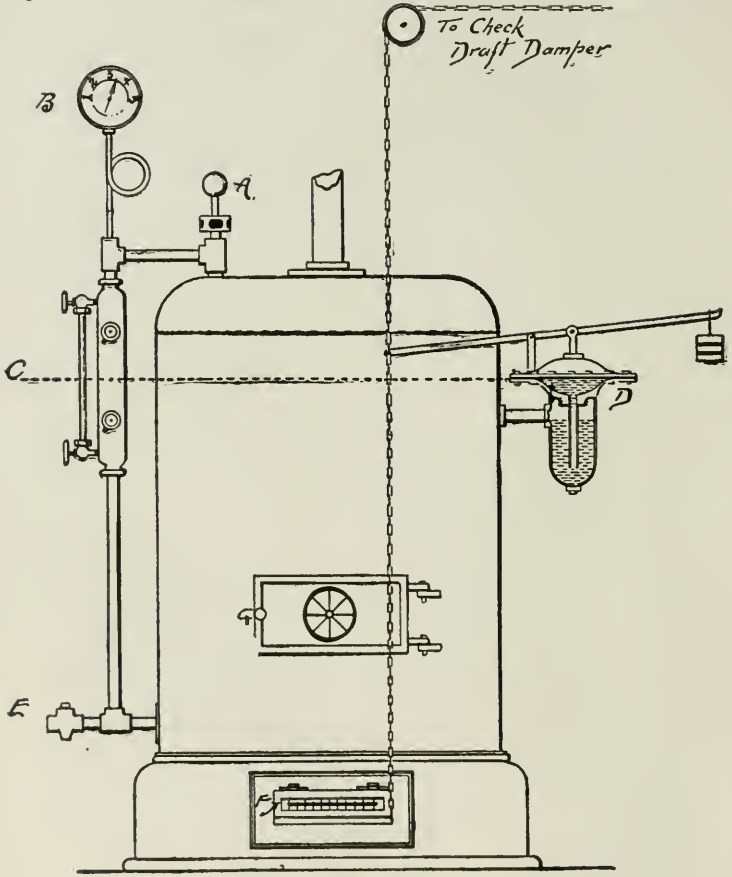


Fig. 131.

points in these various attachments, we make use of the accompanying illustration, Fig. 131.

A low pressure steam heating boiler is not considered complete unless it is provided with one low pressure safety valve, one water column having glass gauge and two try cocks, one low pressure steam gauge, one low pressure damper regulator and one blow-off plug cock.

The boiler should be fitted with a draft door of small size hinged at its upper edge so as to rise and fall by movement of regulator lever.

We will handle each of the so-called boiler trimmings separately, in order to have a proper understanding of each.

The Low Pressure Safety Valve.

It is customary in the United States to set low pressure safety valves to blow off at five pounds pressure, and it is a good plan to select a style valve for house heating purposes that cannot be set at any higher pressure. Therefore the style shown in illustration Fig. 131, at A will answer well for such work. It is important that all such safety valves be of large size, so that any excess of pressure will quickly escape. Nothing less than 1 1-2 inch should be used on even the smallest size house heating boiler. The safety valve should be located as close as practical to the boiler, and in no case to have any other valve between it and the boiler.

The Water Column.

The water column of the steam boiler which is indicated at C., in illustration Fig. 131, should also be of good size, not less than 3 1-2 inches in diameter and 14 inches long with glass gauge and two try cocks as shown in illustration. The top and bottom connections to water column should never be of less size than 1 inch pipe, for the reason that there must be a good and free circulation of the water in the column and its connections, so that any fluctuation of water in the boiler will be readily noticed in the glass gauge and smaller than 1-inch pipe will not always permit of a proper circulation in these connections.

The Low Pressure Steam Gauges.

The proper steam gauge for a low pressure steam warming boiler is one that will only register 5 pounds, and the diameter of such gauge should be not less than 6 inches, this gives a person an opportunity to know when there may be one or two pounds pressure of steam in the boiler on

even a half pound, without having to use a powerful glass to be able to tell whether there is any pressure shown or not. The steam gauge should never be supplied on such boilers with stop-cocks, but a bent pipe as shown only, for the reason that such stop-cocks are often closed and left so, rendering the gauge useless. The bend under the steam gauge, is for the purpose of holding a small quantity of water so that water only presses against the spring of the gauge, so that the spring will not be injured by heat from the steam.

The Blow-Off Cocks.

A very important fitting connected with the low pressure steam heating boiler is the blow-off cock. This is usually located at the lower part of boiler and generally under the water column as marked at E in illustration; this should always be what is known as a straight way plug cock, and so made to require a wrench or instrument to open or close it as required and made of best composition or steam metal only.

This blow-off cock should never be of less size than one inch, as this opening is intended to discharge not only water at times from the boiler, but sediment which will easily choke up smaller openings.

The Low Pressure Damper Regulator.

A low pressure steam heating boiler is a most unsatisfactory thing without a good damper regulator, for the special reason that steam is so uneven in its pressure that without something to automatically take care of such pressure, steam would be impractical for house heating purposes.

It is therefore important that the damper regulator be of proper construction and set in a proper manner.

The low pressure damper regulator consists of two bowl shaped castings having a rubber diaphragm between which lifts a plunger pivoted to a lever; it is desirable to so construct the lever part of regulator to hold a quantity of cold water in order that steam will not come in contact with the rubber, and for this purpose an enlargement is placed on the lower part, having a tube extending down from upper chamber to a point near the bottom while the steam inlet is above the water line in lower chamber, so that when steam pressure is exerted it forces the water up the inner tube against the diaphram.

Locating the Regulator.

It is a most important thing to properly locate the regulator and not only as a matter of convenience in making connections with the draft doors but as to its height, compared with the water line in the boiler.

By referring to illustration Fig. 131, it will be noticed that the diaphrage of regulator is on a line with the water line of boiler, and this is the proper location in regard to the height, all such regulators should be set. The reason for this location of regulator is because when the boiler and regulator are at rest that is when there is no pressure of steam in boiler, there will be the same height of water in the regulator as there stands in the boiler and having the draft doors properly balanced, the slightest rise in pressure of steam will be exerted on the diaphragm, because there is no lift to be overcome before the column of water rises as high as diaphragm, as is always the case where damper regulators are located above the water line in boiler.

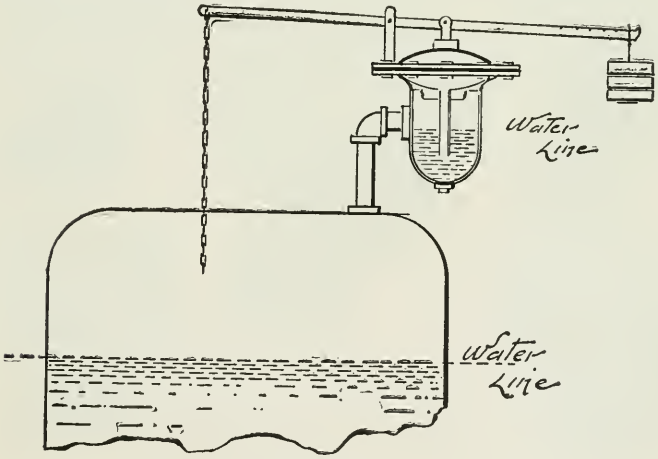


Fig. 132.

To better explain the proper height to set steam damper regulators, we will refer to illustration Fig. 132. This is an improper location, and a close regulation of the draft doors cannot be possible from the pressure of steam; as will be noticed, the pot at bottom of regulator holds water in the usual manner

but it can only hold water to a height equal to the opening for steam connection on side as indicated by the dotted lines. Now we may balance the doors as perfectly as possible, and we will get no movement in the lever shown in Fig. 132, until after there is more than enough pressure to lift a column of water from the water line in lower part of regulator to a height above the center of diaphragm. It will therefore be seen that with one half pound pressure of steam in many cases as such things are set and constructed, there would be no movement of the lever whatever, while if properly located as shown in Fig. 131, there can be a regulation with much less than ½-pound of steam.

Fittings Used in Steam and Hot Water Heating Plants.

In the construction of steam and hot water heating plants, cast iron fittings are used, malleable iron being too soft to stand the action of steam or hot water, and while there are a large variety of shapes and makes of

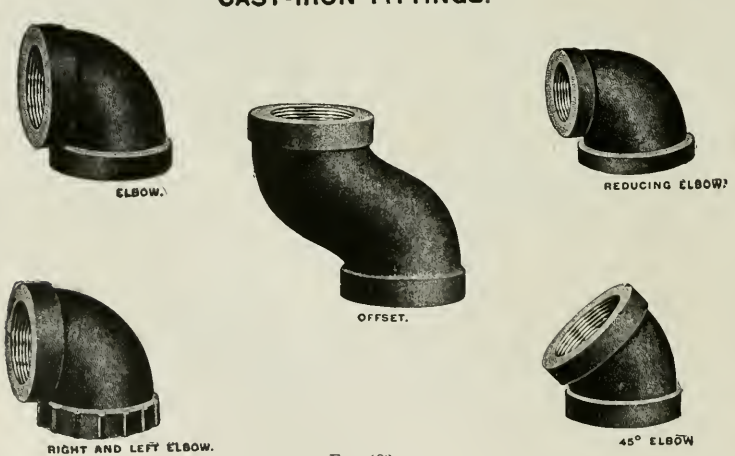


Fig. 133.

fittings, there are but a few principal fittings that are the standard for this purpose, and with these any system may be properly completed.

In Fig. 133 we show the standard make of elbows for steam work, the straight elbow, the reduced elbow, the 45° elbow, and the right and left

elbow. The best indication of a fitter understanding his business is when his work shows the proper fitting used in the right place. There should be no excuse for the use of bushings on any steam or hot water heating plant, as there can be found in the market every size and shape reduced fittings. It is bad practise to use bushings for such work. Forty-five degree elbows can be used to much advantage in many cases at the same time, producing the best results, and in constructing work the fitter should keep his eyes open to just such points. The right and left elbow is known by the ridges on one edge as shown in the illustration, Fig. 133, and this fitting also takes an important part in all construction work. The offset fitting can be worked into advantage when a little thought is displayed,

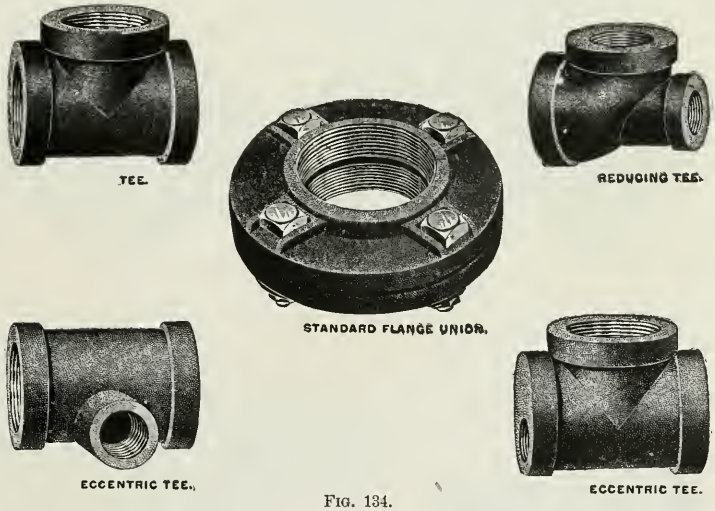


FIG. 134.

as there are so many places where a short offset must be made, and these fittings being of different extensions can be found to answer many situations, which will be better and cheaper than bending the pipe or putting in two elbows to make the offset.

There are also a number of tees but they may be summed up as four: The straight tee, the reduced tee, the side eccentric tee, and the end eccentric tee. These special shapes of fittings when used where they are intended

reduce the number of fittings on the plant and at the same time making the best possible job. When flange unions are to be used, the best is none too good, and the style shown in Fig. 134 will be found satisfactory for low-pressure steam heating work.

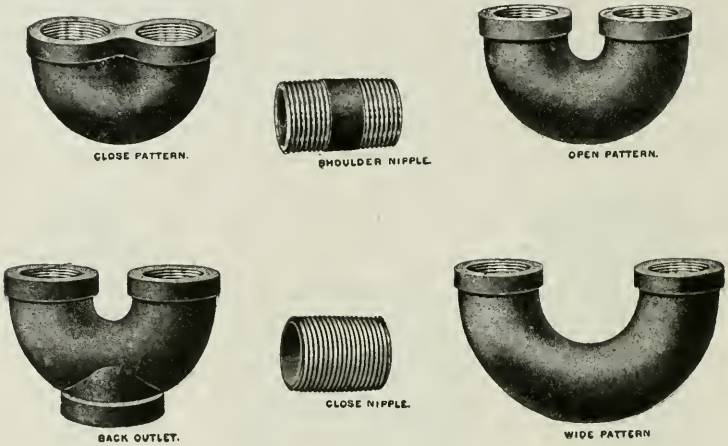


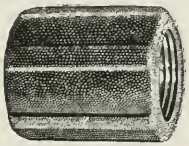
Fig. 135.

Return Bands.

It is important to know the proper names of the various fittings made as well as their special use, and for this reason we show four styles of

Fig. 136.

return bends, all of which are utilized in the construction of heating coils.



RIGHT AND LEFT COUPLING.
Fig. 137.

Branch tees are made in great varieties of sizes and openings so that in the construction of coils, any number of outlets can be had to meet the requirements.

The right and left coupling is also an important fitting in steam construction work, as it can often take the place of a union, thus making a less cumbersome job and at less expense.

The Eccentric Reducer.

This is a fitting that can be used to advantage on horizontal steam supply lines, which enables the fitter to keep the lower part of his pipe in line and at the same time reduce the size, and thereby preventing the accumulation of water in such lines of pipe.

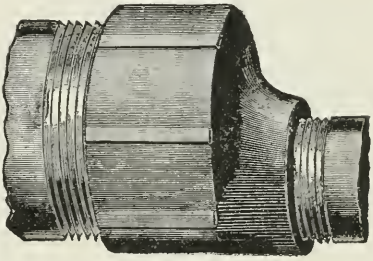


Fig. 138.

The Long Screw, with Coupling and Lock-nut.

There are situations where it is impractical to join two pipes with either a union or right and left coupling, and in such places the long screw can be used, and which makes a perfect and reliable joint.

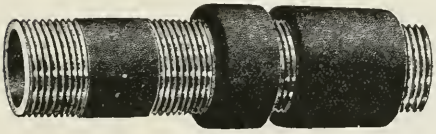


Fig. 139.

When long screws are used, as shown in Fig. 139, the nipple should be of extra heavy pipe, for the reason that such a long thread cut in standard pipe will weaken the nipple too much for good and reliable work.

Wrought Iron Pipe Hangers.

In steam construction work there is no more important matter than that of making proper provision for hanging the pipes, and to bring this

point more clear to the mind of the reader, we show in Fig. 140 a number of standard wrought iron pipe hangers. It must be remembered that in hanging

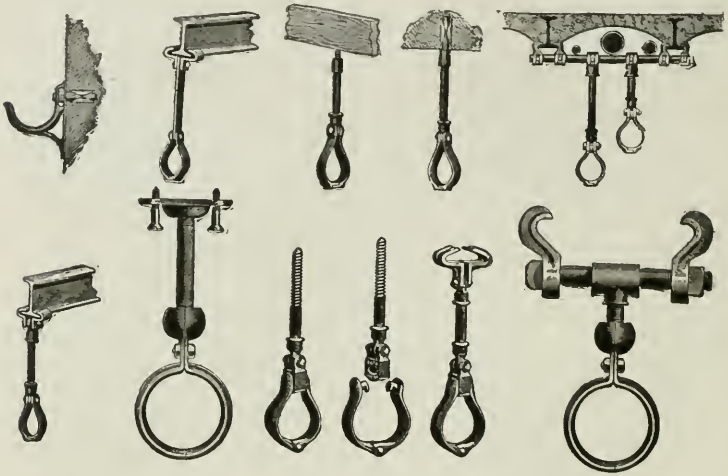


FIG. 140.

steam and hot water pipes, provision must be made for the expansion and contraction of such pipes which is constantly going on while in use by the rise and fall of temperature. Therefore such hangers are made to move in any direction.

We show in Fig. 141 some of the most important makes of hook plates,

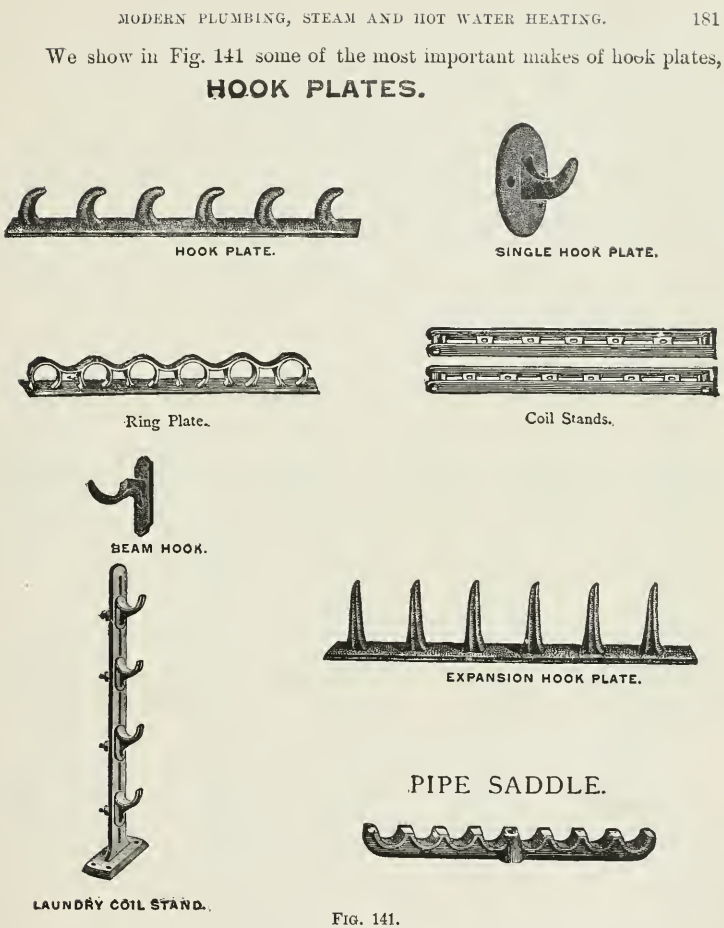


FIG. 141.

which are intended to hold wall coils in proper position, also ceiling and box coils.

HOW TO PROPERLY TAKE MEASUREMENTS OF PIPES AND FITTINGS.

In Fig. 142 we give a diagram of two elbows, a valve, and a tee, with

lines drawn through the center of each fitting, also a lateral line below with arrows indicating the center points of fittings, inside of which the measurements are to be marked. This makes it clear when ordering pipe work with fittings cut to order,

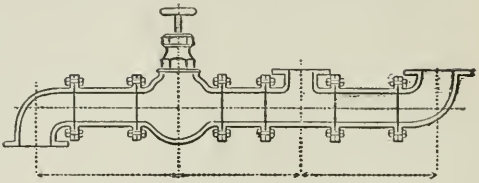


FIG. 142.

so that if the measurements are correctly taken and placed on diagram, there can be no mistakes in getting out such work.

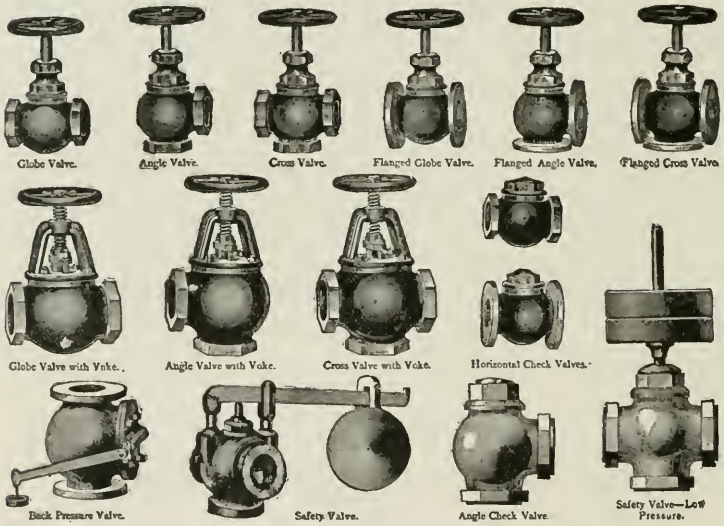


FIG. 143.

VALVES USED IN LOW PRESSURE STEAM HEATING PLANTS.

In illustration, Fig. 143, is shown some of the most important valves used in steam heating plants, giving the name of each under same, as such are called in the trade.

Size of Main Steam Pipes.

In calculating on the proper size of steam mains for gravity heating systems, lengths of such pipes as well as the square feet of surface in same must be considered. In situations where long runs of pipe are necessary between the boiler and radiating surface proper, one size larger pipe should be used for each 100 feet, and at the same time all mains figured as radiating surface when deciding on the sizes of such main pipes.

RADIATING SURFACE PIPE WILL SUPPLY.

Diameter of Pipe.	Area in Inches.	Radiation.	
		Direct.	Indirect.
1¼ x 1	1.49	150	85
1½ x 1¼	2.03	225	140
2 x 1¼	3.35	350	200
2½ x 1½	4.78	500	300
3 x 2	7.38	800	500
3½ x 2	9.83	1100	700
4 x 2½	12.73	1500	1000
4½ x 2½	15.93	1800	1200
5 x 3	19.99	2400	1600
6 x 3½	28.88	3600	2200
7 x 4	38.73	5000	3000
8 x 4½	50.03	6500	4000
9 x 5	63.63	8000	5400
10 x 6	78.83	10000	7000

Steam Piping.

There are many systems of pipe-work in the construction of low-pressure steam heating plants, and each one of which can be made to operate in a successful manner when properly understood and carried out in a proper manner. The two special systems known to the trade are the one and the two pipe methods of steam heating.

We have also what is known as the overhead system, also the one pipe circuit system. What is meant by the one pipe system of steam heating applies especially to the radiator connections, and means that each radiator has but one pipe connected to it which supplies the steam, as well as conveying

away the condensation from the radiator, as shown in illustration, Fig. 144.

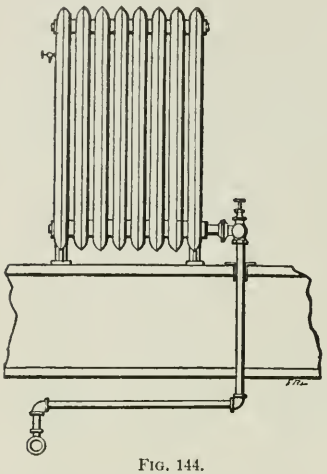


Fig. 144.

This sketch, Fig. 144, shows the proper method of connecting a first floor radiator by the one pipe system, and as will be noticed, the branch is taken from the top of cellar main with a short nipple, then extending to opposite end of radiator from that directly over cellar main, and rising through the floor. The object of this lateral branch from cellar main to radiator, is for the purpose of allowing for expansion and contraction of cellar main, which moves a considerable distance in long lines by the extreme changes in temperature. Therefore this lateral branch from cellar main to nipple, which rises through the floor to radiator, will swing with the movements of main line without breaking or causing the joints to leak.

The One Pipe System Gives Best Results.

Personally the writer gives preference to the one pipe system of steam heating wherever it is practical. There being but one valve to contend with on the radiator, it lessens the chances of disarranging such valves.

In sketch, Fig. 145, we show the method of connecting a radiator with a rising line, which shows the lateral branch between the floor and extending to opposite end of radiator from that of the rising line. This also is for the purpose of allowing for expansion in the riser, which may move an inch or so without injury to the connections.

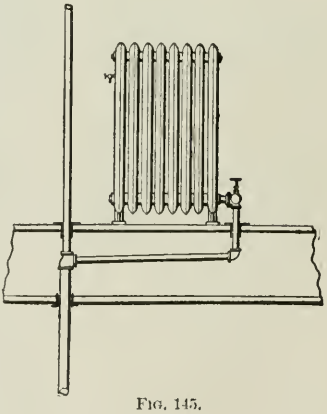
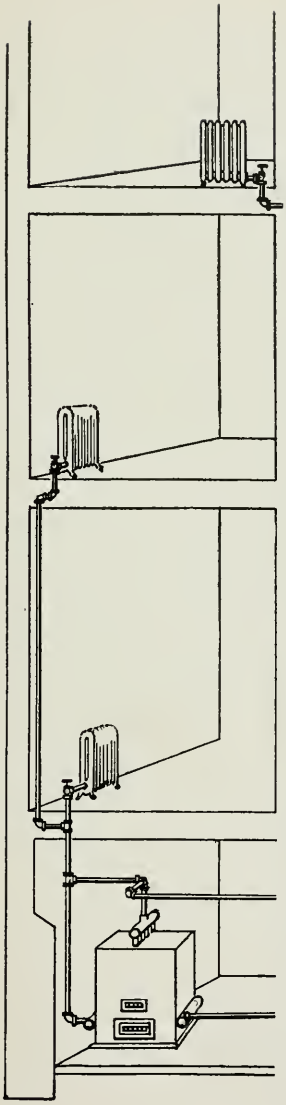


Fig. 145.

As branches and risers on the one pipe system must carry the supply of



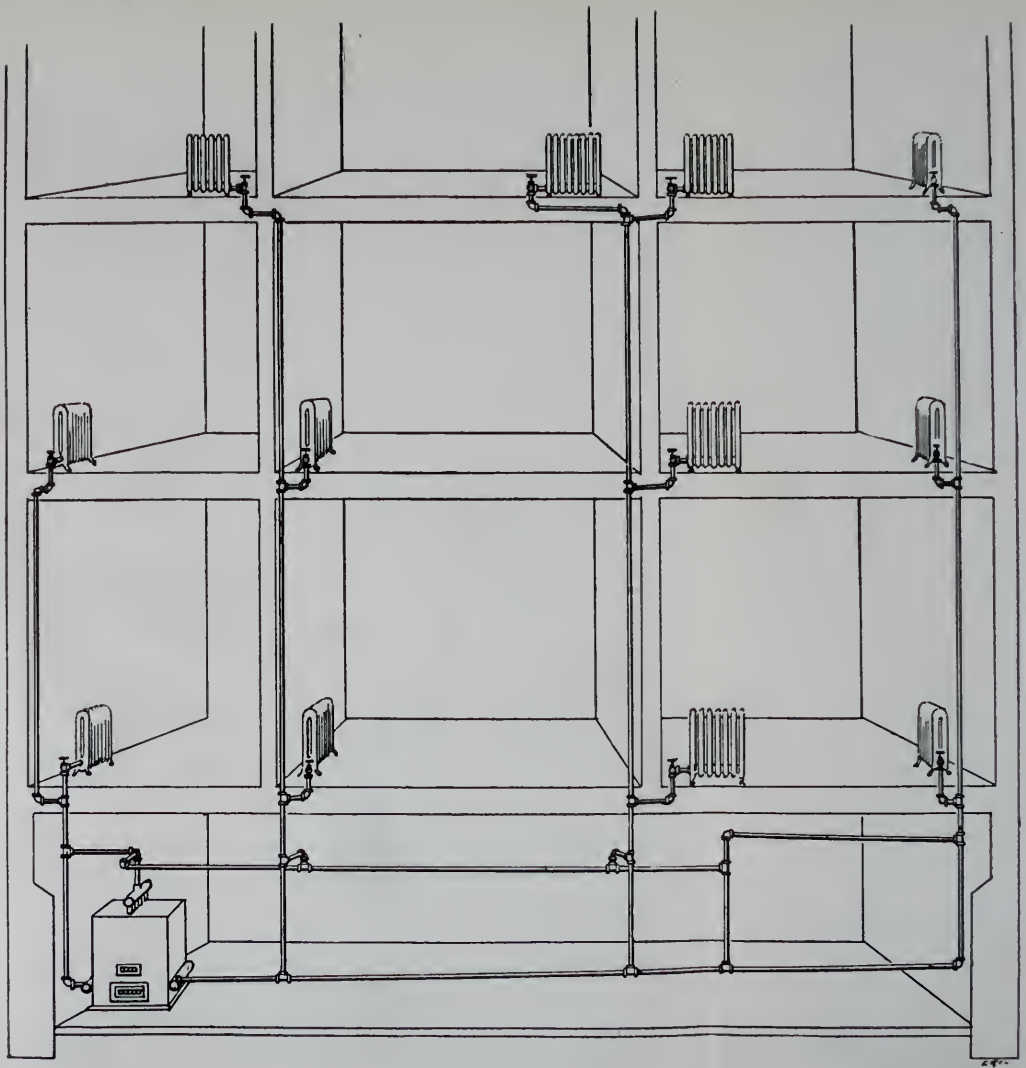


Fig. 146.

steam to the radiators, and also convey back all condensation from radiation, it will be seen that such system of piping must be of larger size than the two pipe method, and for the purpose of showing the proper sizes of such one pipe connections, we refer to the table of sizes and capacities of radiators below, which shows the size of openings in radiators for both the one and the two pipe method of connecting.

RADIATOR TAPPINGS FOR THE ONE AND THE TWO PIPE SYSTEMS.

No. of Sections.	Length. Inches.	One Pipe Openings.	Two Pipe Openings.		Heating Surface. Square Feet.					
			Supply.	Return.	45 in. High.	38 in. High.	32 in. High.	26 in. High.	23 in. High.	20 in. High.
2	5	1 x ○	1 x $\frac{3}{4}$		10	8	$6\frac{3}{8}$	$5\frac{1}{8}$	$4\frac{3}{8}$	4
3	$7\frac{1}{2}$	1 ○	1 $\frac{3}{4}$		15	12	10	8	7	6
4	10	1 ○	1 $\frac{3}{4}$		20	16	$13\frac{1}{8}$	$10\frac{3}{8}$	$9\frac{1}{8}$	8
5	$12\frac{1}{2}$	1 ○	1 $\frac{3}{4}$		25	20	$16\frac{3}{8}$	$13\frac{1}{8}$	$11\frac{3}{8}$	10
6	15	1 ○	1 $\frac{3}{4}$		30	24	20	16	14	12
7	$17\frac{1}{2}$	$1\frac{1}{4}$ x ○	1 $\frac{3}{4}$		35	28	$23\frac{1}{8}$	$18\frac{3}{8}$	$16\frac{1}{8}$	14
8	20	$1\frac{1}{4}$ ○	1 $\frac{3}{4}$		40	32	$26\frac{3}{8}$	$21\frac{1}{8}$	$18\frac{3}{8}$	16
9	$22\frac{1}{2}$	$1\frac{1}{4}$ ○	1 $\frac{3}{4}$		45	36	30	24	21	18
10	25	$1\frac{1}{4}$ ○	1 $\frac{3}{4}$		50	40	$33\frac{1}{8}$	$26\frac{3}{8}$	$23\frac{1}{8}$	20
11	$27\frac{1}{2}$	$1\frac{1}{4}$ ○	$1\frac{1}{4}$ x 1		55	44	$36\frac{3}{8}$	$29\frac{1}{8}$	$25\frac{3}{8}$	22
12	30	$1\frac{1}{4}$ ○	$1\frac{1}{4}$ 1		60	48	40	32	28	24
13	$32\frac{1}{2}$	$1\frac{1}{4}$ ○	$1\frac{1}{4}$ 1		66	52	$43\frac{1}{8}$	$34\frac{3}{8}$	$30\frac{1}{8}$	26
14	35	$1\frac{1}{4}$ ○	$1\frac{1}{4}$ 1		70	56	$46\frac{3}{8}$	$37\frac{1}{8}$	$32\frac{3}{8}$	28
15	$37\frac{1}{2}$	$1\frac{1}{4}$ ○	$1\frac{1}{4}$ 1		75	60	50	40	35	30
16	40	$1\frac{1}{2}$ ○	$1\frac{1}{4}$ 1		80	64	$53\frac{3}{8}$	$42\frac{3}{8}$	$37\frac{1}{8}$	32
17	$42\frac{1}{2}$	$1\frac{1}{2}$ ○	$1\frac{1}{4}$ 1		85	68	$56\frac{3}{8}$	$45\frac{1}{8}$	$39\frac{3}{8}$	34
18	45	$1\frac{1}{2}$ ○	$1\frac{1}{4}$ 1		90	72	60	48	42	36
19	$47\frac{1}{2}$	$1\frac{1}{2}$ ○	$1\frac{1}{4}$ 1		95	76	$63\frac{1}{8}$	$50\frac{3}{8}$	$44\frac{1}{8}$	38
20	50	$1\frac{1}{2}$ ○	$1\frac{1}{4}$ 1		100	80	$66\frac{3}{8}$	$53\frac{1}{8}$	$46\frac{3}{8}$	40
21	$52\frac{1}{2}$	$1\frac{1}{2}$ ○	$1\frac{1}{4}$ x $1\frac{1}{4}$		105	84	70	56	49	42
22	55	$1\frac{1}{2}$ ○	$1\frac{1}{4}$ $1\frac{1}{4}$		110	88	$73\frac{3}{8}$	$58\frac{3}{8}$	$51\frac{1}{8}$	44
23	$57\frac{1}{2}$	$1\frac{1}{2}$ ○	$1\frac{1}{4}$ $1\frac{1}{4}$		115	92	$76\frac{3}{8}$	$61\frac{1}{8}$	$53\frac{3}{8}$	46
24	60	$1\frac{1}{2}$ ○	$1\frac{1}{2}$ $1\frac{1}{4}$		120	96	80	64	56	48
25	$62\frac{1}{2}$	$1\frac{1}{2}$ ○	$1\frac{1}{2}$ $1\frac{1}{4}$		125	100	$83\frac{1}{8}$	$66\frac{3}{8}$	$58\frac{1}{8}$	50
26	65	2 x ○	$1\frac{1}{2}$ $1\frac{1}{4}$		130	104	$86\frac{3}{8}$	$69\frac{1}{8}$	$60\frac{3}{8}$	52
27	$67\frac{1}{2}$	2 ○	$1\frac{1}{2}$ $1\frac{1}{2}$		135	108	90	72	63	54
28	70	2 ○	$1\frac{1}{2}$ $1\frac{1}{2}$		140	112	$93\frac{1}{8}$	$74\frac{3}{8}$	$65\frac{1}{8}$	56
29	$72\frac{1}{2}$	2 ○	$1\frac{1}{2}$ $1\frac{1}{2}$		145	116	$96\frac{3}{8}$	$77\frac{1}{8}$	$67\frac{3}{8}$	58
30	75	2 ○	$1\frac{1}{2}$ $1\frac{1}{2}$		150	120	100	80	70	60
31	$77\frac{1}{2}$	2 ○	$1\frac{1}{2}$ $1\frac{1}{2}$		155	124	$103\frac{1}{8}$	$82\frac{3}{8}$	$72\frac{1}{8}$	62
32	80	2 ○	$1\frac{1}{2}$ $1\frac{1}{2}$		160	128	$106\frac{3}{8}$	$85\frac{1}{8}$	$74\frac{3}{8}$	64

A Complete One Pipe System.

In accompanying illustration, Fig. 146, we show a complete low-pressure steam heating plant on the single pipe system of radiator connections.

In the system of pipe-work shown in Fig. 146, while we have single rising lines to the various radiators, and with single branches to radiators, we have two cellar lines, one being the supply of steam to all radiation, while the other is the return from all radiation. This makes a safe and sure working system, as the various supply pipe in cellar is so graded that it will relieve itself of condensation without obstructing the steam passage, as should also be noticed the branches are taken from top of cellar main, and connecting to the risers with a tee, so that the lower part of risers extends down, connecting with return pipe below the water line of boiler. Thus making each rising line practically independent, so that the circulation will not be interfered with by short circuiting from any other line.

The return pipe should, in this system, drop below the water line of boiler at its greatest distance from boiler, and at the same time start at a high enough elevation above the cellar floor to admit of a fall the entire distance to boiler, as shown in illustration. A special feature which should not escape notice in this one pipe plant, is the method of connecting the steam main to the boiler, first rising, then extending a few feet at right angles with the long lateral line, this allows for the main to swing as it expands and contracts without fear of a break or leak in the fittings. All lines of pipe should be so located as to have free space to move in, from any direction, and in no case to be wedged up close against stone walls or other obstructions, for the reason that no obstruction will hinder the pipes from expanding, and should they not have room to move in a straight direction to their length, the result will be that such pipes will bend, and in so doing stand great chances of breaking some of the fittings and causing the apparatus to leak.

The One Pipe Circuit System of Steam Heating.

What is known to the heating trade as the one pipe circuit system of steam heating, is shown in Fig. 147. It consists of one main pipe extending around the cellar forming a complete circuit of the building. The sketch represents a cellar plan, showing the radiators connected by a single branch. In this system the cellar main starts at as high an elevation above the boiler at A. as the cellar ceiling will permit, having a slight fall away from the boiler all around, so that both the steam and condensation will move in the same direction as indicated by the direction of arrows as shown, still keeping up the main pipe as high as practical above the water-line in boiler until it

has passed the last radiator, when this main pipe may drop vertically as indi-

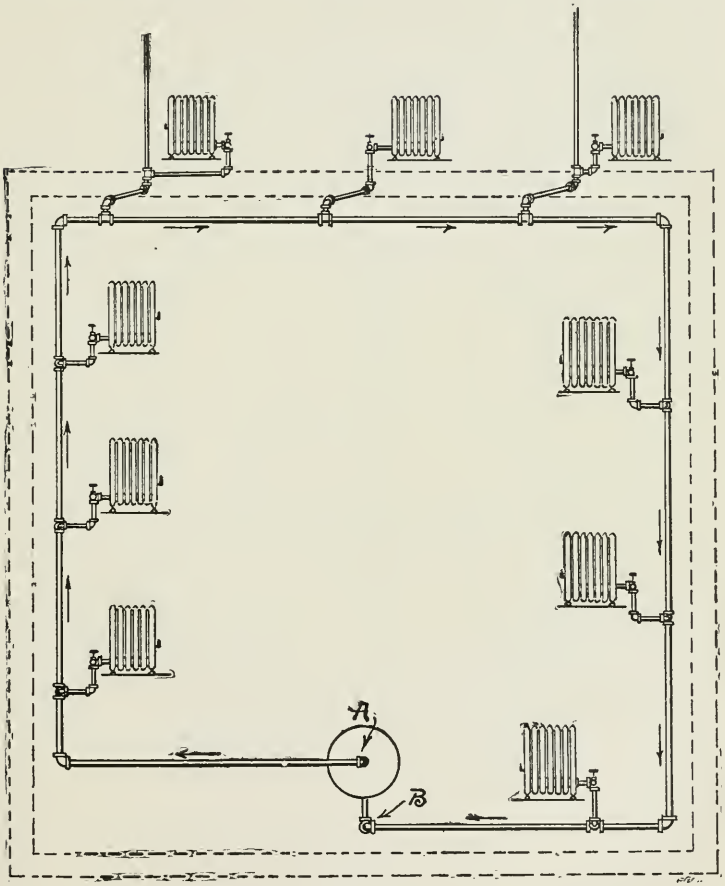


FIG. 147.

cated by B. in illustration, Fig. 147, to bottom of boiler, thus completing the circuit.

All such branches are taken off the top of main, in order to get as dry

steam as possible to each connection. Risers may be carried up from such one pipe circuits to upper stories and operate in a satisfactory manner. In such circuit systems it is not good practise to reduce the cellar main, but carry it full size until it has passed the last radiator connection, when it may be reduced to about one-half its size, taking care at the same time to make the reduced connection with an eccentric fitting, so that water cannot lodge in any part of the main pipe.

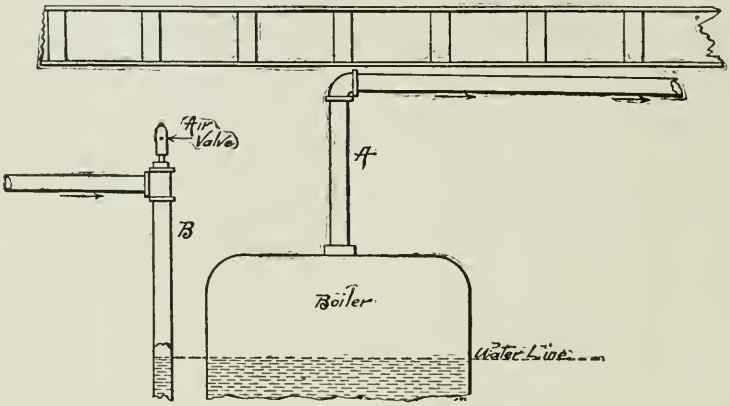


FIG. 148.

To further illustrate the practical workings of the one-pipe cellar circuit system, we refer the reader to Fig. 148, which shows the main where it starts, from above the boiler indicated at A and also the end of same circuit line, returning to boiler as shown at B, which gives about the proportion of pitch around the entire circuit. An important point in such work, in order to have a good and rapid circulation of steam around the entire system, is to place a good automatic air valve on the return line as shown at upper part of pipe B.

A CIRCUIT SYSTEM WITH ONE WET RETURN.

In illustration, Fig. 149, we show a modification of Fig. 147, and while it requires a little more pipe the results obtained will more than pay for the extra cost. As will be noticed, the boiler is placed in the center of cellar at one end, with the main rising as high as cellar ceiling will permit, and in place of turning to one side with an elbow, as in Fig. 147, a tee is used which

allows steam to move both sides, as indicated by the direction of the arrows, the main pipe connecting together again in the center of opposite end from

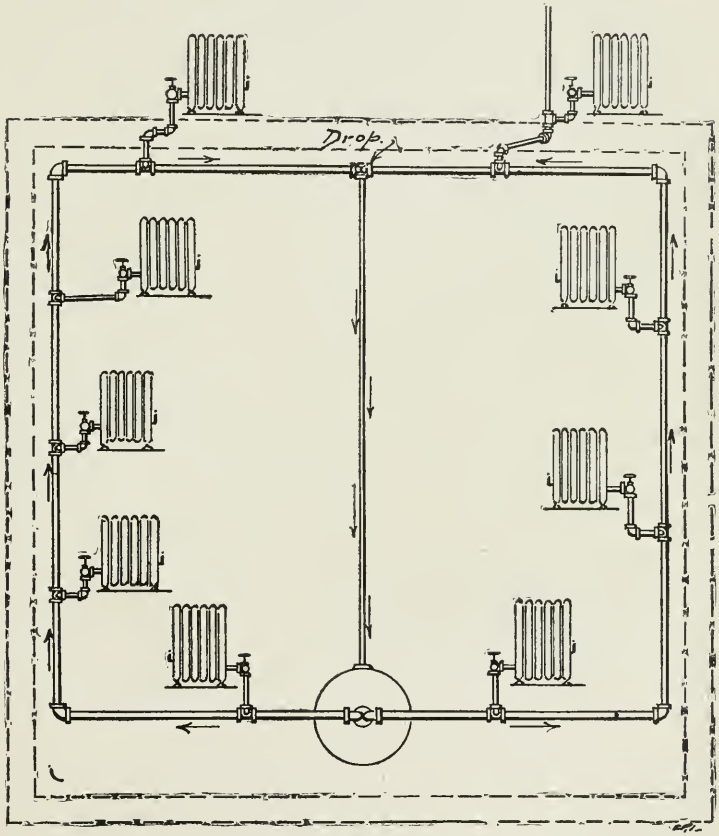


FIG. 149.

boiler still at a point above the water line in boiler, then dropping to cellar floor, where a small return pipe may be placed in a channel under the cellar floor.

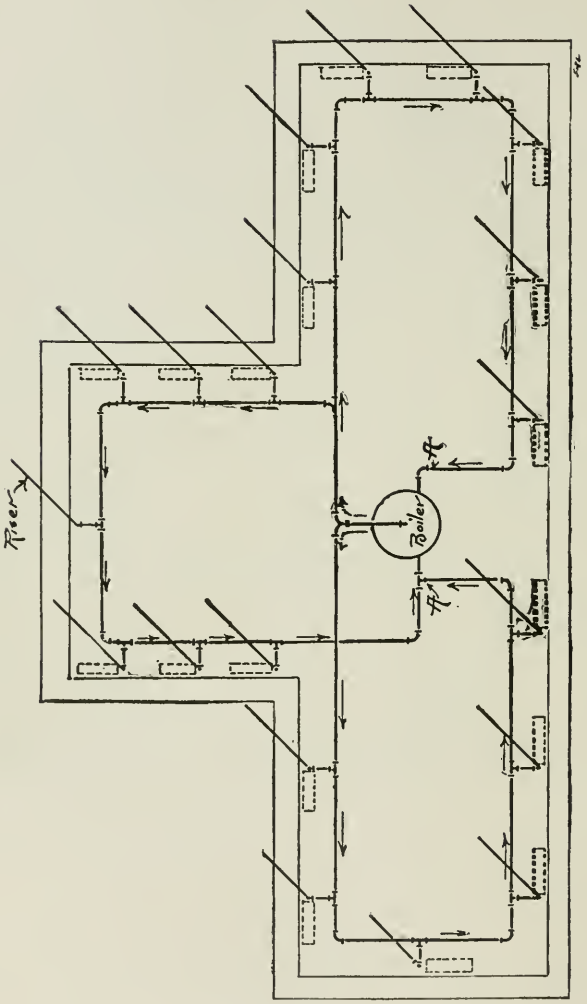


FIG. 150.

The special advantages of the circuit shown in Fig. 149 are that there will be a more uniform supply of steam to the radiation and a more rapid circulation produced throughout the entire system.

At the extreme end of such circuits as stated above, the line must be supplied with an automatic air valve to allow all air to escape from the system.

A Triple Circuit System of One-Pipe Steam Heating.

The combination of circuits that can be made are unlimited, as may be noticed in referring to illustration, Fig. 150.

It depends largely upon the shape of the building how such circuits should be formed, so that while one pipe is used only around the entire building several loops may be formed, which has the advantage of giving a more uniform supply of steam to the various points of the building, and also making it practical to shut off any section of the building without interfering with other departments.

Locating the boiler as shown in the center of building and carrying the pipe with a fall all around the various circuits, as indicated by the direction of the arrows, and dropping vertically at the points marked AA. In this illustration, Fig. 150, the dotted lines show the location of direct radiators on first floor, while the lines shown at an angle of 45° represent rises which may extend to any floor above.

In a system of this kind all pipes are overhead the entire distance of cellar, and as should also be noticed provision is made for the pipes to move by expansion in any direction. Cellar mains should be located about twenty-four inches or so out from cellar walls, so that the branches taken off to radiators or risers will have swing enough to move with the cellar main, and also the rising lines.

The Two-Pipe System of Steam Piping.

In the two-pipe system each radiator is supplied with two connections, one for the supply of steam and the other to carry off the condensation. It is therefore necessary in this system to have two valves to control each connection, and while it is a little the best when room permits to locate such connections or opposite ends of the radiators, they may both be located on the same end of radiators, and many makes of radiators are specially tapped for such connections.

Fig. 151 shows the best systems of double pipe connections. The cellar mains are pitched in the usual manner down from the boiler, so that the con-

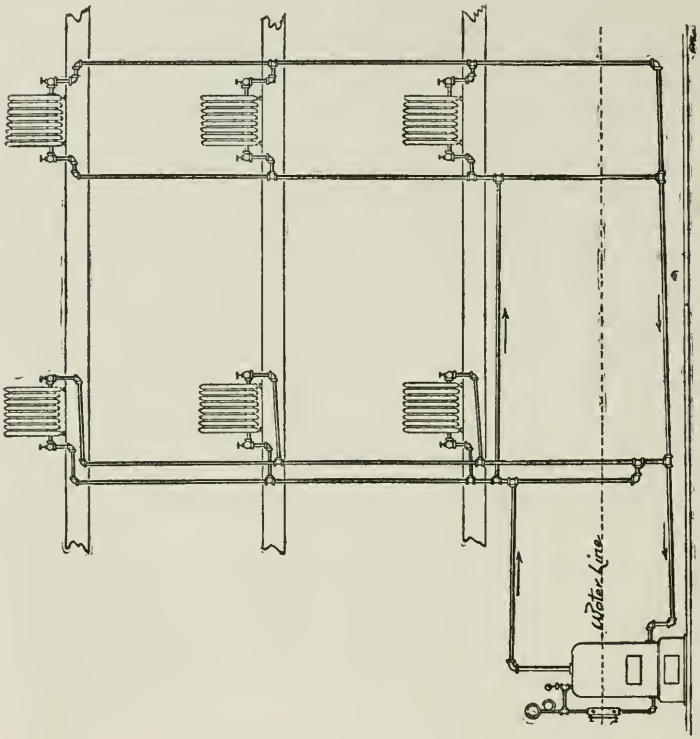


FIG. 151

densation from the mains will flow in the direction of the steam, and it is good practice to relieve the mains as much as practical from such condensation by dropping below the water line, as shown not only at the ends of such lines, but at one or more points between the boiler and end of line as the distance may require.

In the two-pipe system much smaller size pipes will answer for risers and connections to radiators, but it is important to carry each return if possible

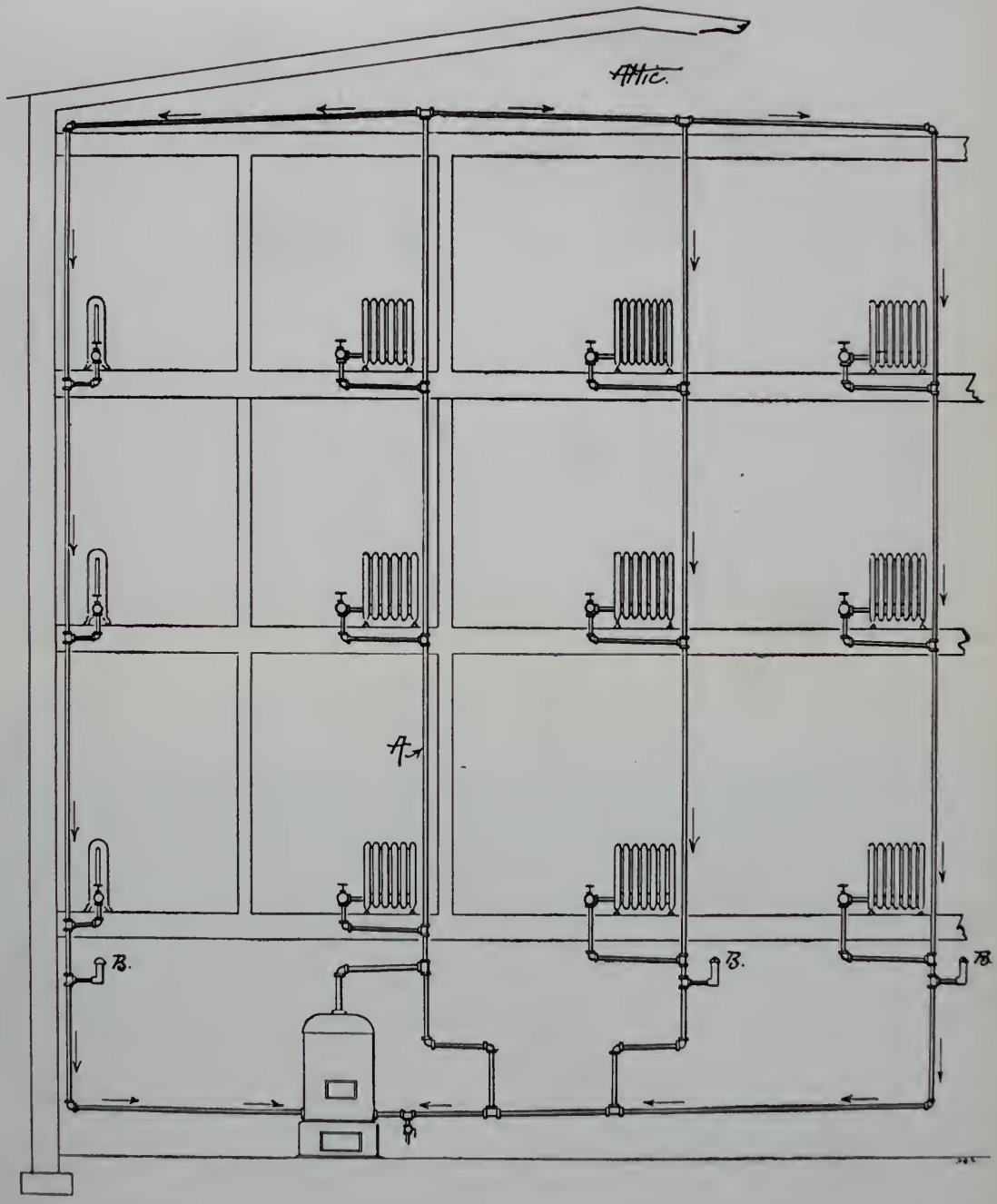


FIG. 152

separately to a point below the water level of boiler before connecting with the main return. This is to guard against what is known as short circuiting of the steam, unless the returns drop into water or are wet returns, the steam from some favorably located radiator would back up through the return pipe of some other radiator less favorably situated and prevent circulation entirely in such radiator.

In rising lines of the two-pipe system, it is optional or a matter of taste whether the pipes are carried both on one side of the radiators, or one on each side, as shown in Fig. 151, yet, where both pipes are carried on one side, it is advisable to make the closest connection; the supply for the steam also as shown, giving a slight pitch to all such lateral branches, so that there will be no chance for condensation to lodge in any parts of such connections.

The Overhead Supply System of Low Pressure Steam Heating.

A system of piping for low pressure steam work which gives excellent results is shown in Fig. 152, and is known to the trade as the overhead supply system.

In this arrangement of pipe work the main supply pipe is carried from the boiler directly to the attic of building, where it then extends to the various drop lines from which the radiators are supplied. A in the illustration represents the main rising line, and should this line be carried near any radiators, such radiators may be supplied as shown from the main rising line.

The steam in this system moves, as shown by the direction of the arrows, also all condensation, and is perfectly noiseless at all times.

With overhead systems there is nothing better than the one-pipe connection to radiators, the double connection being unnecessary.

To make sure of having a perfect circulation of the steam down to the lower radiators on the drop lines, it is an excellent plan to use good automatic air valves located in return pipes as shown at B B B as high up near the cellar ceiling as is practical, of good size. As air is heavier than steam, it will drop to the low points and escape through the automatic air valves. With air valves located as shown, it will not be necessary to have air valves of any kind on any of the radiators; this has been practically proved by the writer in many plants.

Radiating Surface Required to Heat Any Size Room.

There is perhaps no question connected with the steam and hot water heating business of so much importance as that of finding the proper amount

of radiation to heat any given space in buildings. And therefore there is more guesswork on this point by the average fitter than on any other point connected with the trade. And while we have from time to time made many experiments to get at something tangible regarding this question, there has been no universal rule discovered that can be set down as absolutely correct, or which can be used in any and every situation. We therefore must still rely upon practical experience and judgment in perhaps nine cases out of every ten. Yet we have discovered some simple methods of calculating the necessary amount of radiation to some degree of accuracy, which saves much time and trouble.

It is the general custom in the United States of America to make provision in the heating plant to warm the atmosphere of the building to a temperature of 70°, with the exterior atmosphere at zero, so that the radiation allowed for the above conditions may be increased if a lower temperature of the exterior atmosphere must be provided for in the same proportion. In other words, we make provision for a rise in temperature between the exterior and that of the interior atmosphere of 70°, so that should we desire a less range of temperature, it will be simply necessary to deduct from the radiation in the same proportion as we deduct from the range of temperature necessary. For simplicity of calculating we base all figures on low pressure steam direct radiation, and then add to this according to other styles of radiation used such as direct indirect, or indirect steam, or direct hot water radiation. There being so many conditions to contend with in the various situations, shapes, and makes of buildings, that it would be impossible to produce a system that would answer in all cases.

A condition of the exterior atmosphere which is the most difficult to contend with in providing proper heat for any building is the velocity and direction of the wind. It is a well-known fact that with a still exterior atmosphere at zero, a building may be 70°, while on the other hand, with the exterior atmosphere at even 20° above zero, and the wind blowing the same, heating plant will often be found to be insufficient to keep the interior atmosphere to 70°. Therefore it will be seen that the slightest change in the velocity of the exterior atmosphere makes a vast difference to working of the heating plant.

In calculating the necessary radiation for any given house or building, the construction of such building must be considered as to the kind of outside walls, their thickness, and material. A house with brick walls on the outside

will require less heat than walls constructed of wood and plaster. Heights of ceilings in rooms make also a difference; for example, a room ten feet square and ten feet high will require more radiation to heat it than one-half as much as a room ten feet square and twenty feet high, and so it is with a large room in length and width compared with smaller rooms having the same height ceilings. Ventilation must be also taken into consideration and provision made to renew the air of the various rooms at least once an hour, and all such points have something to do with the correct amount of radiation required.

Glass surface or outside windows will cool more air than an outside wall without windows, and outside or exposed walls are greater cooling surfaces than walls inside of rooms that are not exposed to exterior atmosphere, and experience has taught us approximately the difference in cooling effects in these various surfaces. It will therefore be seen that the only safe plan to follow in figuring the radiation of a building is to take each room separately, measuring its cubical contents, its glass surface, and its exposed wall surface.

Basing our calculations on a good frame house, with outside walls of studding four or five inches thick, sheathed on outside with one-inch boards, and covered with sheathing paper, properly sided with good laps, also lath and plaster on inside, it is known that one square foot of glass exposed to exterior atmosphere will cool as much air as ten square feet of exposed wall. Therefore these two surfaces may be figured separately or based on equivalents, so that allowing for a change of air each hour. We give the following simple system of getting the radiating surface:—

Glass Surface.

Allow one square foot of direct steam radiation, for each three square feet of glass.

Exposed Wall Surface.

Allow one square foot of direct steam radiation, for each 30 square feet of exposed wall.

Cubical Contents.

Allow one square foot of direct steam radiation for each 100 feet of space or contents of room.

Example.

If we have a room 13 feet wide, 15 feet long, and 10 feet high, as shown in Fig. 153, with one side and one end exposed to the exterior atmosphere,

and having two windows as shown, we proceed to find the necessary radiation as follows:—

We first find the cubical contents of the room, which is 1,950 cubic feet. This we divide by 100, and the result is 19½ square feet of radiation; next the

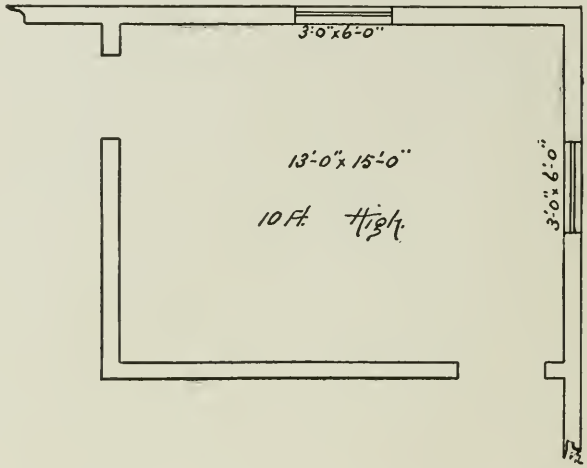


Fig. 153.

exposed wall surface is taken, which is found to be 244 square feet. This exposed surface is divided by 30, and the result from this division is eight square feet and a small fraction. The glass surface in the two windows is yet to be measured up, and as they are each 3 × 6 feet, the total amount of glass will be 36 square feet, and, as stated above, the glass surface is to be divided by three; therefore 36 ÷ 3 gives 12 square feet of radiation. We have now the three amounts of radiation, which when added together equals 19½ + 8 + 12 − 39½ square feet of direct steam radiation necessary to heat the room given in Fig. 153. This rule is intended for first floors, and for rooms above the first floor from 10 to 20 per cent. less radiation will answer.

This system equalizes each room to be warmed, giving it the proper proportion of radiation, not only according to its size, but exposure and amount of glass surface.

Outside Doors must be figured the same as glass surface, and in measur-

ing windows the entire width and height of sash should be taken. Even with the above system of getting the radiation there must be some judgment exer-

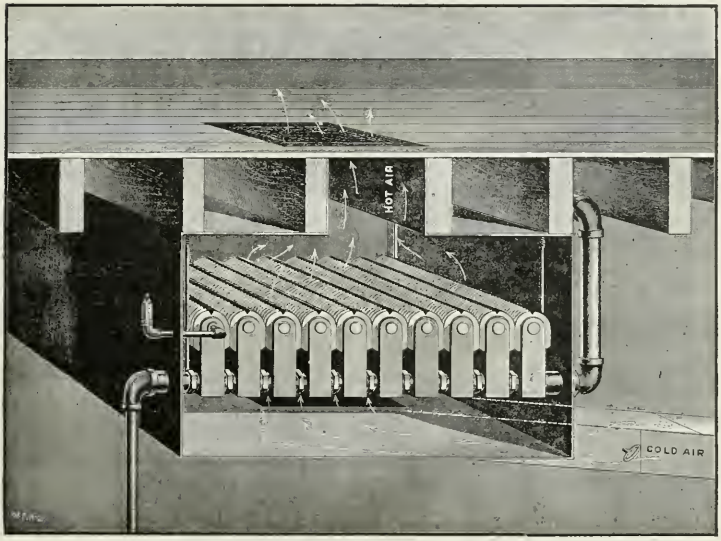


FIG. 154.

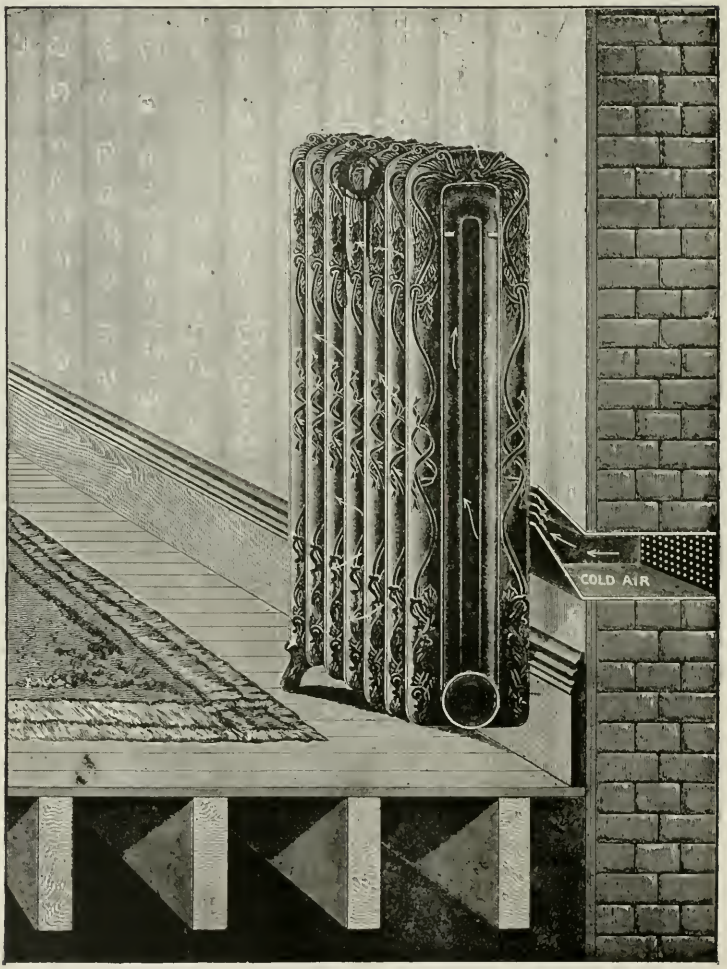
cised in distributing the radiation according to the points of compass. It is a good plan to add a little extra radiation for rooms situated on the north side of the house, and deduct it from rooms on the south side of the house.

WHERE MORE VENTILATION IS REQUIRED.

As stated, the above system of getting the necessary radiation surface is based on allowing one change of air each hour; it will be simply necessary to add to the surface according to the more frequent changes of air that may be desired, for example: Should we desire to change the air every thirty minutes it will be necessary to double the amount of radiation given above.

INDIRECT RADIATION.

To get the proper amount of indirect radiating surface for low pressure steam heating, 50 per cent. more surface is necessary than where direct sur-



CROSS SECTION VIEW SHOWING INTRODUCTION OF AIR.

Fig. 155.

face is used, so that to warm the room, as shown in Fig. 153, by indirect radiation, 60 square feet of radiation would be required.

Direct Indirect Radiation.

If direct indirect radiation is used, as shown in Fig. 155, 25 per cent. additional surface is added over that of direct, which would make it necessary to use 50 square feet to warm the same room (Fig. 153).

Radiating Surface for Hot Water Heating.

It requires more radiating surface for hot water heating than is necessary for steam, for the reason that the average temperature carried in a hot water system is much lower in temperature than the temperature of steam. We refer at present to the open hot water system which is never carried as high in temperature as the boiling point.

The average temperature of open tank hot water systems scarcely carry the water higher than 170°, while steam at about three pounds pressure gives a temperature of about 220°, it will therefore be seen that there is a difference of 50° between the two systems of heating, and consequently it will be necessary to add this percentage of additional radiating surface for hot water heating over that laid down for steam, no matter whether it is direct, direct indirect, or indirect. It will also be seen that it requires about 23 per cent. more radiation for hot water than for steam.

Yet a little more than 23 per cent. of radiating surface for hot water over that required for steam will be found more satisfactory, and to make the matter of calculating the hot water radiation simple, we recommend the following method:

Glass Surface.

One square foot of direct hot water radiation to two square feet of glass.

Exposed Wall.

One square foot of direct hot water radiation to 25 square feet of exposed wall.

Cubical Contents.

One square foot of direct hot water radiation for each 75 cubic feet of air space.

The three amounts added give the necessary direct hot water surface for first floor rooms.

ELASTIC FORCE, TEMPERATURE AND VOLUME OF STEAM.

Elastic Force.		Temperature of Steam Corresponding to its Pressure.	Relative Volume Bulk of Steam Compared to Bulk of Water.	Average Rise of Temperature for 1 lb. Pressure for each 10 lbs.
Apparent Pressure of Steam in lbs. per square inch.	Absolute Pressure in inches of Mercury.			
0	30.0	212.0	1710.0	
1	32.03	215.5	1912.0	
2	34.07	219.0	1523.0	
3	36.11	222.0	1442.0	
4	28.15	225.0	1372.0	
5	40.18	227.5	1312.0	2.8
6	42.22	230.0	1248.0	
7	44.27	232.5	1194.0	
8	46.30	235.0	1168.0	
9	48.33	237.5	1103.0	
10	50.37	240.0	1061.0	
11	.....	242.0	.....	
12	.....	244.0	.....	
13	.....	246.0	.....	
14	.....	248.0	.....	
15	60.56	250.0	895.0	1.75
16	.....	252.0	.....	
17	.....	253.5	.....	
18	.....	254.5	.....	
19	.....	256.0	.....	
20	70.75	257.5	718.0	
21	.....	259.0	.. ..	
22	.....	260.5	.....	
23	.....	262.0	.....	
24	.....	263.5	700.0	
25	80.91	265.0	684.0	1.5
26	.....	266.5	.....	
27	.....	268.0	.. ...	
28	.....	269.5	.....	
29	. ...	271.0	.....	
30	91.12	273.5	614.0	

A TABLE OF THE QUANTITY OF WATER WHICH AIR IS CAPABLE OF ABSORBING TO THE POINT OF MAXIMUM SATURATION, IN GRAINS PER CUBIC FOOT FOR VARIOUS TEMPERATURES.

Degrees Fahr.	Grains in a cubic foot.	Degrees Fahr.	Grains in a cubic foot.
10	1.1	85	12.43
15	1.31	90	14.38
20	1.56	95	16.60
25	1.85	100	19.12
30	2.19	105	22.0
32	2.35	110	25.5
35	2.59	115	30.0
40	3.06	130	42.5
45	3.61	141	58.0
50	4.24	157	85.0
55	4.97	170	112.5
60	5.82	179	138.0
65	6.81	188	166.0
70	7.94	195	194.0
75	9.24	212	265.0
80	10.73		

DIAMETER OF STEAM SUPPLY PIPES AND SQUARE FEET OF RADIATING SURFACE THEY WILL FURNISH WITH STEAM FROM 9 TO 625 FEET FROM THE BOILER.

Steam Pressure 3 Lbs. Per Square Inch, 222°.

Diameter of Pipe in Inches.	Distance of Radiator From Boiler, in Feet.							
	9	64	100	225	324	400	484	625
	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.
¾	240	90	72	48	48	36	32	29
1	494	185	148	98	82	74	68	59
1¼	863	324	259	172	144	129	118	103
1½	1361	510	408	272	226	204	185	163
2	2796	1049	839	559	466	419	381	335
2½	4884	1831	1465	977	814	732	666	585
3	7700	2887	2310	1540	1283	1155	1050	924
3½	11823	4246	3797	2264	1887	1698	1544	1358
4	15819	5932	4745	3164	2636	2372	2157	1898
4½	21226	7959	6368	4245	3537	3184	2894	2547
5	27997	10361	8289	5599	4666	4144	3768	3315
6	44230	16586	13269	8846	7372	6634	6031	5307
7	64013	24005	19204	12802	10668	9602	8729	17681
8	89615	33605	26884	17923	14936	13442	12220	10754
9	120275	45103	36082	24055	20046	18041	16401	14433
10	156277	58604	46883	31255	26046	23441	21310	8753

DIAMETER OF STEAM SUPPLY PIPES AND SQUARE FEET OF RADIATING SURFACE THEY WILL FURNISH WITH STEAM FROM 9 TO 625 FEET FROM THE BOILER.

Steam Pressure 5 Lbs. Per Square Inch, 227.5°.

Diameter of Pipe in inches.	Distance of Radiator From Boiler, in Feet.							
	9	64	100	225	324	400	484	625
	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.
¾	288	110	88	59	48	44	40	35
1	604	224	181	121	100	90	82	72
1¼	1058	397	317	211	176	158	135	127
1½	1669	626	500	334	278	250	227	200
2	3434	1288	1030	686	572	515	468	412
2½	5980	2242	1794	1196	996	897	815	717
3	9436	3539	2831	1887	1572	1415	1290	1132
3½	13899	5212	4170	2779	2316	2085	1895	1667
4	19430	7286	5829	3886	3271	2914	2649	2331
4½	25958	9734	7787	5191	4326	3893	3540	3114
5	35133	13175	10540	7026	5855	5270	4791	4216
6	53433	20037	16030	10686	8905	8015	7286	6412
7	78439	29414	25531	15687	13076	12765	10651	11412
8	109517	41068	32855	21903	18253	16427	14934	13142
9	137053	55144	44116	27410	25642	22058	20052	17646
10	191360	71760	57408	38272	31893	28704	26094	22963

DIAMETER OF STEAM SUPPLY PIPES AND SQUARE FEET OF RADIATING SURFACE THEY WILL FURNISH WITH STEAM FROM 9 TO 625 FEET FROM THE BOILER.

Steam Pressure 10 Lbs. Per Square Inch, 240°.

Diameter of Pipe in Inches.	Distance of Radiator From Boiler, in Feet.							
	9	64	100	225	324	400	484	625
	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.	Sq. ft.
¾	366	137	109	73	61	55	50	44
1	752	282	225	150	125	112	102	90
1¼	1312	492	393	262	218	196	179	157
1½	2074	777	622	415	345	311	281	249
2	4244	1591	1273	848	707	636	578	509
2½	7436	2788	2231	1487	1239	1115	1014	892
3	11702	4388	3510	2340	1950	1755	1595	1404
3½	17205	6452	5161	3441	2884	2580	2346	2064
4	24042	9016	7212	4808	4007	3606	3278	2884
4½	32292	12109	9687	6458	5382	4843	4403	3873
5	42013	17505	12604	8402	7002	6302	5729	5040
6	67564	25337	20269	13513	11260	10134	9213	8107
7	97372	36514	29211	19473	16228	14605	13278	11684
8	136209	51078	40862	27242	22701	20431	18574	16344
9	182955	68608	54886	36591	30492	27443	24948	21954
10	237973	89240	71392	47594	39662	35696	32451	28556

In Fig. 156 we show an indirect stack of steam radiation, showing the best method of constructing this part of a heating apparatus, in order that the air will circulate through the entire surface of the indirect stack. The fresh air should be introduced at the bottom on the opposite end of outlet for the warm air as shown in illustration.

Size of Fresh Air Inlets to Indirect Stacks.

Where natural draft is depended upon for the movement of cold air to the indirect stacks of steam radiation, practice has found that for each square foot of radiation one and one-half square inches of opening for cold air supply is necessary, or, in other words, for each 10 square feet of indirect radiation 15 square inches of cold air opening will answer.

In forming casings around indirect stacks, the sides and ends should be about one-quarter inch from radiating surface, and the distance in depth between the bottom of radiators and bottom of casing to allow the cold air to freely circulate under all parts of such radiation should be from seven to eight inches. The space above the indirect radiators and ceiling should be

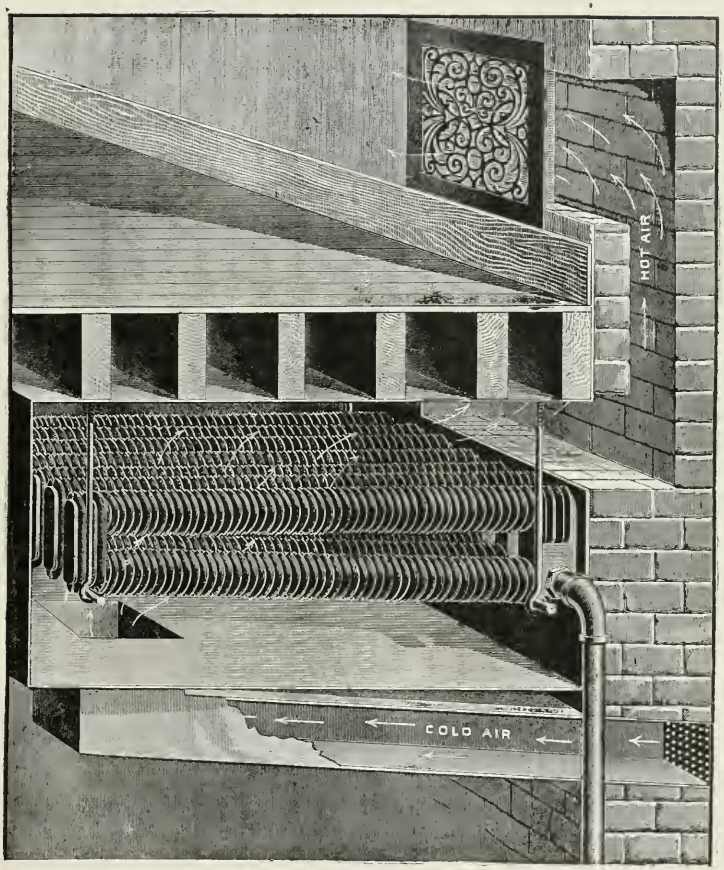


FIG. 156.

greater than that below, and 10 to 12 inches in height will be found to answer all purposes.

Indirect stacks of steam radiation should in all cases be supplied with automatic air valves of good and reliable make.

To Guard Against Freezing of Return Pipes.

In making the return connections from indirect stacks, care must be exercised to protect the return pipes from the cold air which comes in through the cold air box, and this connection must pass through the lower part of casing or the cold air channel; it should be covered with some good non-conducting material.

Cold Air Supplies to Indirect Stacks Should be Provided with Thermostatic Regulators.

In low pressure steam heating plants, even with such as receive the best of attention, there will be an uneven flow of steam through the system. The steam will often fall rapidly through various causes, and as steam condenses quickly indirect radiating surface would soon cool as the cool air comes in direct contact with it. Therefore it will be seen that there is often great danger of freezing the condensation in the stack when steam is allowed to go down, therefore all such cold air inlets should be provided with dampers or valves that would automatically close off the cold air supply to the stack the instant such stack became cool, and so arranged to automatically open again as soon as steam again circulated through the radiation.

This arrangement would not only prevent the indirect stack foom freezing up and being destroyed, but it would prevent the house from freezing from the cold air passing in through the cold radiator, at such times when there was no steam to heat the air.

Pipe Coils and How to Make Them.

In Fig. 157 we show a pipe coil with an expanding end, and while this style coil is largely used along walls in upright position as shown, it is also used as ceiling coils in a flat position. This style coil is perhaps the most satisfactory, as it is easy to construct and gives a good circulation besides allowing for expansion. The object of the right angles formed by elbows on one end is to allow the pipes to move as they expand and contract without throwing the lines out of

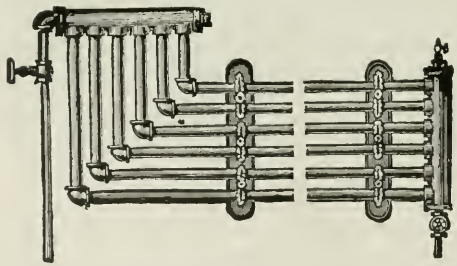


Fig. 157.

position. In the construction of such coils right and left hand elbows are used.

Another style of wall coil is shown in illustration, Fig. 158. This is constructed of return bends, and as each return bend is independent to the others, expansion is taken care of. This style of coil is less effective as the circulation will be less rapid, the steam having to travel a greater distance. Coils as well as radiators must be provided with air valves, and these should be located at a low point for steam as the air falls to the lowest point, yet such valves should be kept up high enough to prevent water escaping.

WALL COILS.

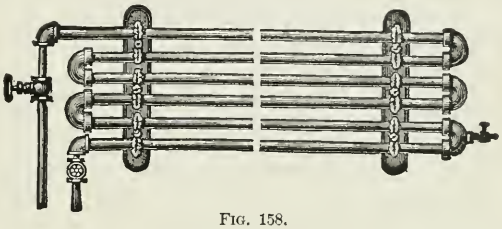


FIG. 158.

Expansion of solids from 32° to 212°, lengths at 32° being = 1.

Brass	1.00191
Common Brick	1.00055
Cast Iron	1.00111
Cement	1.00144
Copper	1.00175
Fire Brick	1.0175
Glass	1.00085
Granite	1.00079
Lead	1.00284
Marble	1.0011
Sandstone	1.00174
Steel	1.00119
Tin	1.002
Wrought Iron	1.00126

TAPPING FOR RADIATORS.

ONE PIPE WORK.	TWO PIPE WORK.
Less than 24 feet, 1 inch pipe.	Less than 30 feet, $1 \times \frac{3}{4}$.
Over 24 feet up to 50 feet, $1\frac{1}{4}$ inch pipe.	30 to 60 feet, $1\frac{1}{4} \times 1$.
Over 50 feet up to 90 feet, $1\frac{1}{2}$ inch pipe.	50 to 100 feet, $1\frac{1}{2} \times 1\frac{1}{4}$.
Over 90 feet up to 150 feet, 2 inch pipe.	100 to 160 feet, $2 \times 1\frac{1}{2}$.

INDIRECT RADIATORS.

30 to 50 feet, $1\frac{1}{4} \times 1$.
50 to 100 feet, $1\frac{1}{2} \times 1\frac{1}{4}$ inches.
100 to 150 feet, $2 \times 1\frac{1}{2}$ inches.

The fitter in constructing steam heating plants, where the one-pipe system is used, often meets with situations where long horizontal lateral branch lines are necessary, and unless such long branches are of large size pipe, and with considerable elevation to the radiators, there are often bad results, on account of poor circulation. A system of pipe connections for this purpose, which is even better than one large pipe, is shown in the accompanying sketches, Figs. 159 and 160. This is done by forming a loop with two small pipes between the main cellar circuit line and the rising nipple to the radiator, as shown in elevation, Fig. 159, while Fig. 160 is a prospective sketch of the same. In systems of this kind the best results will be obtained by using on the main line four way tees, one outlet of which is on the side level with the bottom and in eccentric position, so that there will be as much height as possible between the entrance of the return water and the outlet on top for the steam in the same fitting. In the arranging of this loop, the elbow directly above the main supply pipe is the highest point, and from this the steam line is pitched down, so that all condensation from this line of pipe moves in the same direction of the steam, and on arriving at the extreme end of the loop it is relieved by passing down through the bottom outlet of the tee, returning with the condensation from the radiator to the bottom of the main circuit line. The

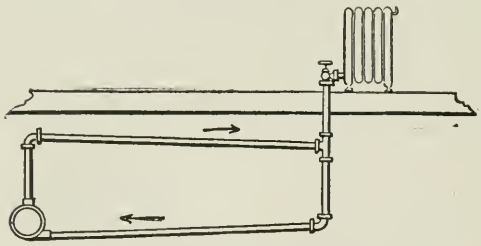


Fig. 159.

rising nipple to the radiators in this system are increased in size from that of pipe in the loop, as both the steam to the radiator and condensation from it must pass through the nipple. In running the loops, both pipes are pitched down in the direction of the arrows shown on sketches. The special reason why such an arrangement of long loop would give a better circulation than one large pipe with an elevation up the entire distance to the radiator, is, because in the case of the loop any steam that might condense in the upper pipe of the loop would flow in the direction of the radiator, and to the extreme end of the loop.

This condensation would immediately warm every inch of the loop, which would prepare the way, *as might be stated*, for the live steam, which can only travel in a warm place to be of any advantage. This lateral loop or branch from the main cellar line would form a complete circuit in itself, and be warm all along at all times with steam in the system, even though the radiator valve be closed. And this is quite an advantage, for the reason that steam will enter the radiator as soon as the valve is opened, having to simply pass up the distance of the valve. The one-pipe cellar circuit system is good also for the same reason, as stated above, the highest point being directly above the boiler and gradually pitching down as it passes around the circuit, keeping, however, above the water line in the boiler until passing the last radiator on the line, where it may fall as low as the bottom outlet of boiler to which it is connected. The condensation in this pipe, it will be seen, proves a benefit in place of being a detriment to the circulation, because all water of condensation, with whatever heat it may have, passes along the entire circuit, and, therefore, keeps this large main line of pipe warm at all times, whether radiators are in use or not, and, this being the case, the most distant radiator on the line from the boiler can have heat in a few seconds after opening the radiator valve, providing, of course, that there is some steam in the system.

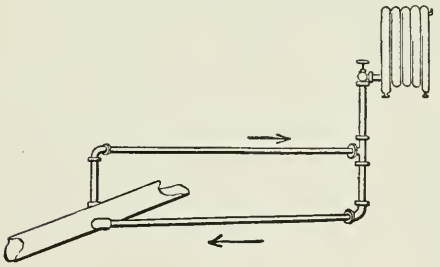


Fig. 160.

The Gold Pin Indirect Radiator.

There are a great variety of radiators for indirect heating in the market, but for simplicity in erecting as well as results in heating and circulating, in

INDIRECT "PIN" RADIATOR.

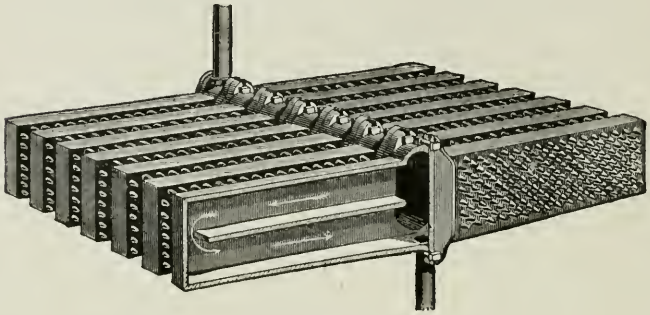


Fig. 161.

the judgment of the writer, there is no make that will give better satisfaction than the style shown in Fig. 161.

Fig 162.

The pattern shown is put together by bolts which slip in between open lugs so that one section is tightened up at a time, making each joint separate and independent to the others.

The joints are in the center, so that one opening only is to be contended with, and this is faced off. Between each surface a thin pasteboard washer is used with thin red lead, which makes a perfect joint.

Referring to the illustration, Fig. 161, it will be noticed that the interior of the sections are divided by a partition placed in about the center as shown, this allows for a good circulation from center to each end of each section, as the steam will flow in the direction of the arrows.

Automatic Air Valves for Indirect Radiators.

As previously stated, there can be no satisfactory results in the circulating of steam through indirect stacks of

steam radiation without having such stacks supplied with good automatic air valves, for the reason that such stacks are located in the cellar of the building and often in places not easy of access; and while there are numerous makes of valves for this purpose, the writer has never found one better and very few as good as the one shown in Fig. 162. This make of valve is known to the trade as the Breckenridge Indirect Air Valve. The exterior part or body of this valve is made of cast iron, while the same is made of brass for direct radiation, and is shown in Fig. 163, and is provided with a drop pipe connection as shown, for the purpose of carrying off any steam, air, or water that may escape from its opening.

The Breckenridge air valve operates automatically by the expanding and contracting of a flat brass rod, which is affected by rise and fall of temperature of the steam passing from the radiator. The expanding brass rod is indicated by A in Fig. 164, which is held rigid at each end, allowing only the center part to move, which bends back in the form of a bow, pulling with it the valve, thus closing the opening when expanded by the heat of steam.

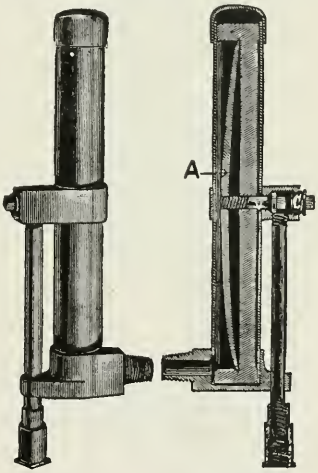


Fig. 163. Fig. 164.

Air Valves for Direct Steam Radiation.

The regular style positive air valve for steam radiation is shown in Fig. 165.

This is provided with a wood handle so that the fingers will not be injured by heat in operating the same.

Steam radiation of any kind will be found very unsatisfactory most of the time where positive air valves are used only, for the reason that each time the steam falls in the apparatus air will accumulate in the radiators, and therefore must be let out by hand each time, otherwise the radiation will give out no heat. The opening therefore of such positive air valves are neglected by the domestic help, and the general results are bad.

An automatic air valve which has given excellent results in direct steam

radiation is shown in Fig. 166, and this is known as the Jenkins Automatic Air Valve.

Referring to the sectional view of the Jenkins valve, A is the inlet; B adjustment for setting; C expansion elastic plug; D outlet tapped for one-eighth inch pipe, or for screwing a finished drip-cup (not shown) on the valve.

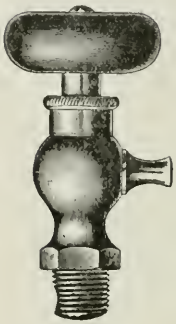


Fig. 165.

The illustration shown is full size of the Jenkins Automatic Air Valve.

An automatic steam air valve quite similar to that just described is shown in Fig. 167, and this is known to the heating trade as the American, Jr.

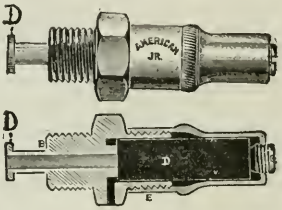


Fig. 167.

The special feature in this air valve is that on its inner end, as indicated by D D in Fig. 167, it is provided with an enlargement in its diameter whichis claimed acts as a drip, preventing condensation as it

JENKINS' AUTOMATIC AIR VALVE.

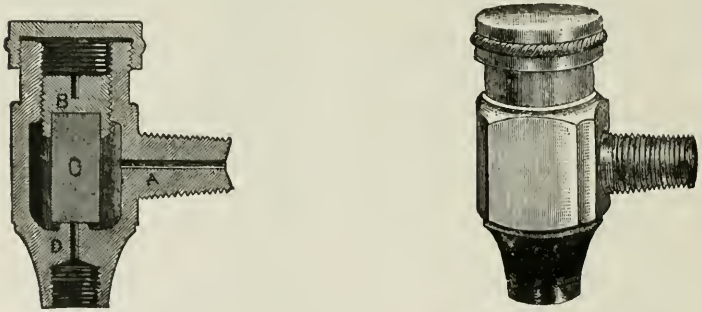


Fig. 166.

falls from the inner walls of radiator from choking the outlet with water.

The expanding post being similar to the Jenkins, which is composed of a composition of hard rubber.

Automatic Steam Air Valves with Floats.

A feature in automatic air valves which has given a considerable amount of annoyance, is the escapement of water or condensation, and to

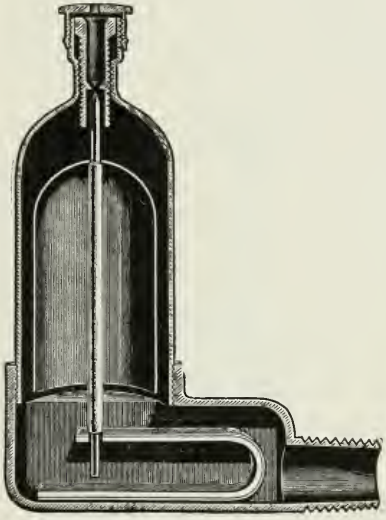


Fig. 168.

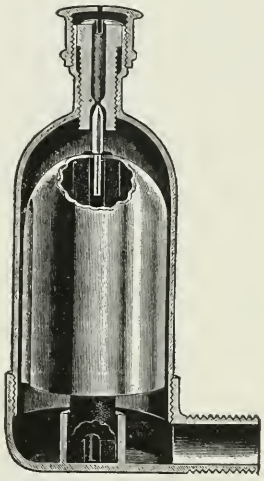


Fig. 169.

overcome this objection valves have been constructed that will open and close by temperature and also close with water, thus making it unnecessary to place drip pipes from each radiator. A construction of this kind is shown in Fig. 168. This is the Onderdonk Air Valve shown in section, the U-shaped rod in the lower part bends up and down by the rise and fall of temperature carrying with it a float in the upper part and closing the outlet. Should the expanding rod, which is a combination of metal, fail to close perfectly tight and water find its way into the valve the float is supposed to rise by its buoyancy power and close the outlet against the escapement of water.

Another modification of automatic float steam air valve is shown in Fig. 169, called the Royal.

This is provided with expanding pillar of hard rubber located on the

inside of the float as shown, which operates in a similar manner to that just described.

A SPECIAL DIFFICULTY WITH AUTOMATIC STEAM AIR VALVES is water logging, which means that after condensation is formed in the valve, the water of condensation remains in the valve in place of passing back into the radiator, thus rendering the valve useless, as at such times the water cannot move into the radiator or out from the valve, and this is the great difficulty with practically all makes of automatic float steam air valves.

RADIATOR VALVES FOR LOW PRESSURE STEAM WORK.

A most important thing connected with steam heating plants of the low pressure gravity system is the proper selection of valves, and especially those used on radiators. This refers particularly to the kind of seat such valves should have, and to make this point more clear we show a valve in section, Fig. 170, which has what is known as a soft seat, and not of the ground metal surface pattern. For the special reason that the slightest leak of steam into a radiator when it is turned off would cause a great amount of annoyance. The ground metal seat cannot be relied upon for this class of work for any length of time, as the slightest gritty substance finding its way under the ground seat would cause same to leak just enough to make noise in such radiator.

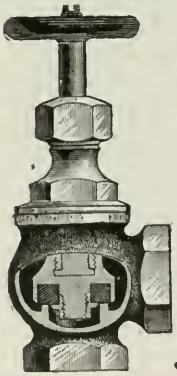
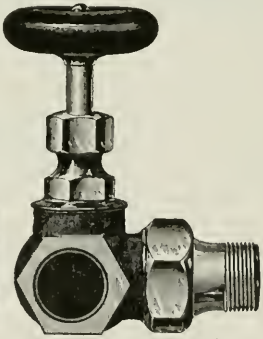
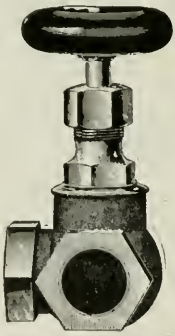


FIG. 170.



CORNER VALVE, WITH UNION. RIGHT-HAND.

FIG. 171.



CORNER VALVE. LEFT-HAND.

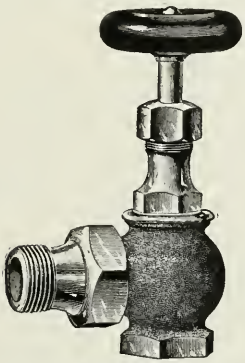
FIG. 172.

In planning the pipe-work of a steam plant the fitter should keep his eyes open to the matter of neatness in radiator connections, and the best way to

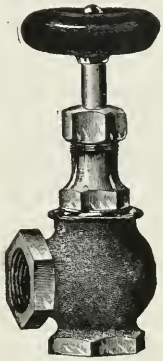
secure the neatest job is to use valves and fittings that are specially made for particular situations which may be encountered.

The angle radiator valve is one that can often be used to advantage over that of the regular pattern.

The angle radiator valve is shown in Figs. 171 and 172, and are intended to be used where the supply or return lines to radiators are carried above the floor for some distance and passing back from radiator at right angles.



RADIATOR VALVES, WITH UNION.
FIG. 173.



RADIATOR VALVES, FEMALE.
FIG. 174.

The regular pattern radiator valve is shown in Figs. 173 and 174, both with and without unions.

How to Set Globe Valves on Steam Heating Plants.

The globe valve is not a good construction for use on low pressure steam heating work, for the reason that in any position it adds a large amount of friction and retards the flow of steam.

In such heating plants there are some positions in which this make of valve might be placed by incompetent persons which would entirely cut off the circulation of steam although such valve might be open. To explain this point, we show a globe valve placed in a horizontal line of pipe with the stuffing box in an upright position, and, as will be noticed, the entire passage-way for steam is obstructed by condensation. We will suppose the direction of the steam along the pipe is in the direction of the arrows, and as the seat of the valve is located in the center, the lower section of valve forms a pocket

in which the condensation must rest, and causing the water of condensation to back along the supply side of valve as shown by the dotted lines in Fig. 175.

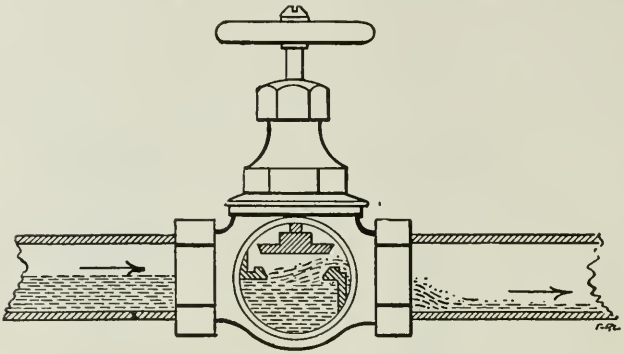


Fig. 175.

Steam at very low pressure could not pass this point, and therefore circulation would be shut off, and should there be sufficient pressure of steam to force its way through such a water trap it would result in a most disagreeable noise, so that the occupants of a house in which such a piece of work may be installed would think they had a blacksmith-shop in their cellar.

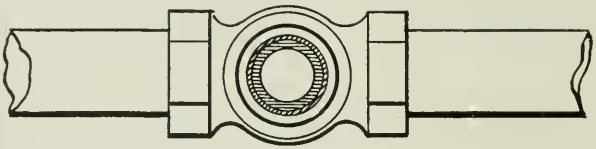


Fig. 176.

If globe valves are used at all in horizontal lines of steam pipe, they should be placed as shown in Fig. 176, with the stem or cap placed on the side, so that condensation will pass along without forming a water seal in the pipe.

Radiation in Low Pressure Steam Heating Plants Below Water Line of Boiler.

There are two ways by which heat may be had from low pressure steam heating plants at points below the water level of the boiler, and while these two special points are known to the average fitter, there are many persons

practicing this line of trade who have had no experience with such systems, but who often meet situations where radiation below the water line would be desirable. The illustration, Fig. 177, will serve to show how the pipe-work of such radiation may be practically carried out. In the illustration B represents the steam boiler, from which steam may be carried to the various radiators situated above the boiler and having the usual return pipes to bring back back the condensation to the boiler.

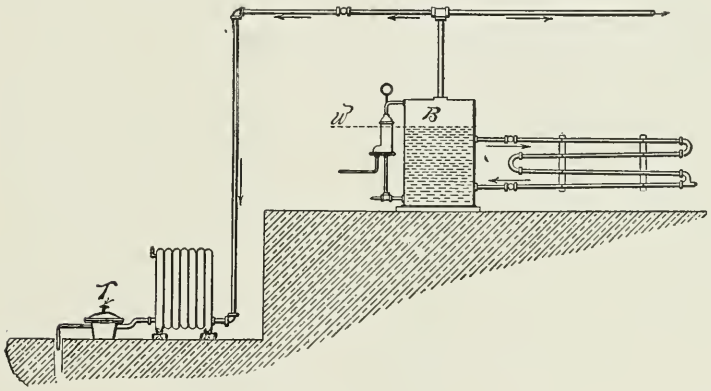


Fig. 177.

The highest point to which water rises, or the water level, is indicated by W, and on the right side of boiler is a return bend coil, all of which is situated below the water level, and which can be used as radiating surface. Through this coil the water from the steam boiler can be made to circulate, and will be found to be very effective. Both connections of the coil should be provided in such cases with valves as shown, and while one valve would answer the purpose of stopping the circulation, it is always best to provide against a leak in the coil so that a valve in each branch to the boiler might save trouble and annoyance. Then where such radiation as shown on the right of boiler is used, provision should always be made to drain the coils of water when not wanted for heating purposes in cold weather, and this can be done by placing a plug at some point on the lower pipe in such coil. If the pipes to hot water radiation of this kind are carried as shown, there will be no

necessity of air valves, as all air will pass to the boiler and escape through radiators situated at some higher elevation. Any style of hot water radiation can be used for such purposes, as well as pipe coils, by simply carrying out the same general principle of producing circulation.

On the left of the boiler in the illustration is shown another kind of radiation at a point below the boiler, and in this case steam is used, but the condensation does not return to the boiler, and therefore provision is made in this case so that there will be no escapement of steam and at the same time completely draining the radiator. At the outlet end of this style radiation is placed a steam trap, as indicated by T, the discharge pipe from which connects with a waste or drain pipe. There are a few special points connected with this arrangement of radiation, which must also be remembered, to guard against damage from freezing. And, as will be noticed, the radiator is elevated, so that all water will fall from it into the steam trap by gravitation, then, again, the one valve for controlling the supply of steam to this radiator is located near the main steam pipe above the boiler, so that at times when this valve is closed there will be no chance for water to stand in any part of the steam pipe to the radiator where it might freeze. An automatic air valve will be necessary on such radiation in order to keep up a circulation of the steam at all times during cold weather, for the reason that it would be possible to stop circulation by the accumulation of air in the radiator with an ordinary direct air valve, and with the steam supply valve on main pipe wide open, and under such circumstances it would be possible for the water to freeze in the steam trap, thus closing the outlet and allowing the radiator and all connections to it to fill with water. Therefore it will be seen that this is a very important place to use the best make of automatic air valve. In regard to the supply valves on all lines, if globe valves are used, they should be placed at an angle of 45°, as shown in illustration, in order to prevent trapping of these lines, but gate valves in such places may be placed at any angle. In heating systems of this kind where steam radiation is located below the water level of the boiler and condensation from such surface discharged through steam traps, there will be a loss of water from the boiler to the extent of such condensation, and on this account it will be necessary to place on the boiler a reliable automatic water feeder connected to the water service supply to keep the water up to its proper height in the boiler at all times, and not alone to save attention but to protect the boiler.

A Simple Method of Finding the Length of Pipe Required in 45° Angles.

In the pipe fitting of steam and hot water heating plants 45° elbows are brought into use quite extensively, and it is not every mechanic who has mastered mathematics sufficient to be able to figure square root in order to find the hypotenuse of an angle, and on this account we give the following method of getting the measurements of 45° angles, which will be close enough for any such pipe-work.

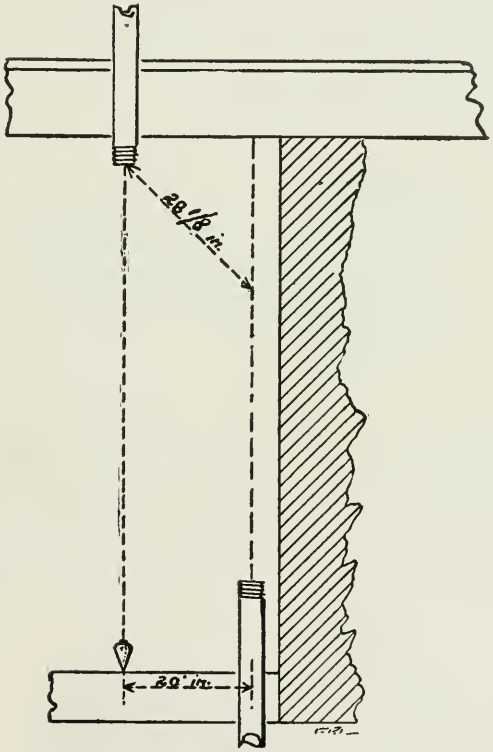


Fig. 178.

For each inch of offset add $\frac{13}{32}$ of an inch, and the result will be the distance from center to center of the 45° angle.

Example.

Referring to illustration, Fig. 178, we will suppose that a pipe is to be brought up from a lower floor near a wall, and it is to pass through the ceiling of the room at a distance of 20 inches farther away from the wall than that which it rises through the floor, as indicated in the illustration by the figures 20 inches, which is shown by the plumbob. This shows that the distance in a straight line from center to center of the two points is 20 inches, now it is simply necessary to add to the 20 inches 20 times 13, and divide the result by 32 to get the additional length necessary for the 45° angle—$20 \times 13 = 260 \div 32 = 8\frac{1}{4}$, the result of the fraction, being $8\frac{1}{4}$, is added to the 20 inches, which makes the distance of the angle, as shown, $28\frac{1}{4}$ inches.

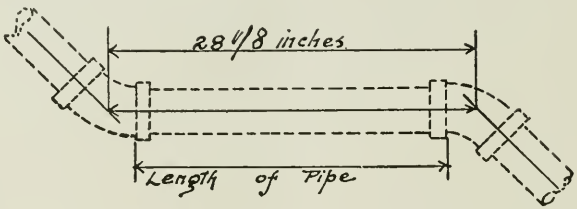


Fig. 179.

In any case it will be necessary to allow for the distance taken up by the fittings from center to center of same, as shown in Fig. 179.

By this system it will make no difference how many inches the offset may be; simply add for each inch an additional fraction of $\frac{3}{32}$ of an inch. Again, suppose the offset is to be five inches, we multiply 5 by 13, which gives us 65. We now divide the 65 by 32, which gives us $2\frac{1}{32}$, this product of the fraction we now add to 5 inches, which is the distance of offset, and we have $7\frac{1}{32}$ inches from center to center of the 45° angle, or any distance in the same manner.

Expansion of Iron Pipe for Each 100 Feet in Inches from 30°.

Temperature.	Expansion in Inches.
165°	1.15
215°	1.47
265°	1.78
297°	2.12
338°	2.45

Automatic Water Feeders for Low Pressure Steam Boilers.

Any device that will add to the safety of a steam boiler is surely an improvement to a steam heating apparatus, and as there is danger with steam boilers when the water is allowed to fall too low in them, the automatic water feeder is used as a precaution to guard against any such trouble. And while some of the primitive makes of these devices had many objectionable features and were not always reliable, the more recent constructions are quite up to the standard of other appliances connected with steam heating plants.

LOW PRESSURE WATER FEEDER.

For Automatically controlling the Water Level of Low Pressure Heating Boilers.

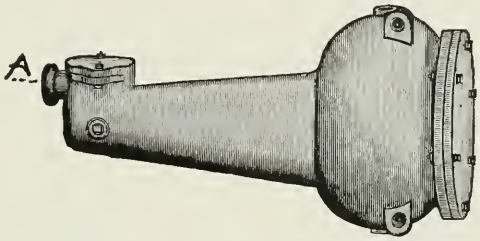


Fig. 180.

In illustration, Fig. 180, we show one of the first patterns of water feeder, and one of the valves which controlled the supply of water, the inlet being at A in the illustration, which was above the water level, would therefore be surrounded with steam, which greatly affected the rubber washer, causing it to harden and lose its elasticity in a short time.

NASON'S "IMMERSED-VALVE" BOILER FEEDER.

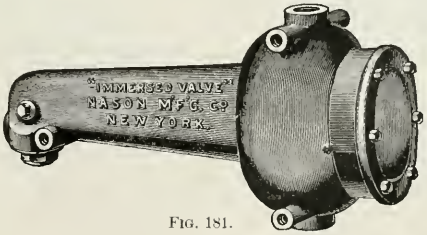


Fig. 181.

The objectionable feature mentioned above has been overcome in a more recent construction, known as the Nason Water Feeder, and shown in Fig. 181.

The following is what the makers have to say regarding Fig. 181 :

As hitherto made, all automatic water feeders for boilers have been so constructed that the valve which governs the amount of water requisite for the boiler has been placed at the top of the feeder, where the rubber seat is constantly exposed to the destructive action of steam, which is at or above a temperature of 212°.

This rapidly destroys the gummy nature of the rubber in the valve, leaving behind it a hard residuum which speedily crumbles, and it has therefore at frequent intervals to be renewed.

The difficulty has now been avoided by inverting the valve, its position being beneath the water, where, as it is always kept wet and at a lower temperature, its durability is thereby greatly increased.

Among its most important advantages are the following:

All the copper floats used in them are made "extra strong" and carefully tested under pressure, in order to avoid to the greatest possible extent a danger common to all of them, that of collapsing.

The lever connecting the float with the valve is made as long as the form of the casing permits, a quarter turn in it between the valve and fulcrum enabling all interior space to be fully utilized.

Easy access is had to the valve with the least possible trouble by removal of the brass cap immediately below it; and the large opening facilitates its replacement with a new one, if injured or worn out.

It is not advised that these regulations be attached to boilers where the pressure exceeds twenty pounds, although as a matter of precaution, they are carefully tested to fifty before leaving the factory.

They may be used with or without a gauge glass, to be placed upon either side—holes being tapped for this purpose.

Outlets for the glass gauge are made on both sides of the feeder in order that it may be connected in either side of the boiler as most convenient.

Directions for Using.

Place the regulator near the boiler at such a height that its center coincides with the line at which it is desired to maintain the water level in the boiler.

Connect the top opening on the large end of the receiver with the steam dome of the boiler above the water line, and the bottom opening with the boiler at some point below the water level.

The feed water connection is then to be made with the small end of the feeder—care being taken in all cases to ascertain that the pressure in the water supply exceeds the greatest amount of pressure which the boiler is ever to be used under.

For the benefit of purchasers, the following dimensions are given, which may be of assistance in connecting the feeder.

Outside length	$23\frac{1}{4}$ inches.
Height	$13\frac{3}{8}$ "
Width	9 "
Size of boiler connection	1 "
Size of gauge glass connection	$\frac{1}{2}$ "
Size of feed water inlet	$\frac{1}{2}$ "

Other modifications of the automatic water feeder for low pressure steam heating boilers of quite recent construction are shown in Figs. 182, 183, 184,

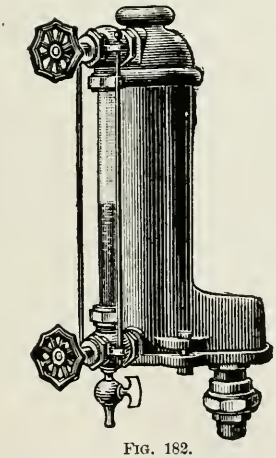


FIG. 182.

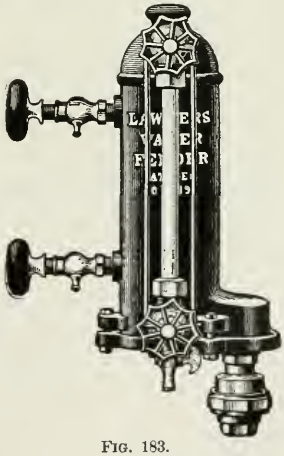


FIG. 183.

185, and 186. All of which are manufactured by the Lawler Water Feed and Damper Regulator Company of New York City.

These water feeders are quite small in size compared with older makes, thus taking up less room in setting same. Some of the special features in the Lawler Water Feeders are as follows:—

They are constructed in the shape of a water column, long and narrow, and are intended to dispense with the use of water columns on steam boilers where these feeders are used, and as will be noticed they are provided with a glass water gauge, as shown in Fig. 182, and also supplied with glass water gauge and try cocks, as shown in Fig. 183. The connections to boiler are simple, as shown in Fig. 184, which makes it unnecessary to provide such pipe connections for an extra water column, this saving in time and material as well as space around the boiler.

In setting water feeders it is important to place a check valve on the water supply pipe to feeder, so that water cannot be syphoned out of the boiler through the cold water supply pipe from any cause, and to make sure that these feeders will be set with check valves, all the Lawler Water Feeders are provided with check valves set in the supply connections, and another precaution is taken to guard against trouble—a fine strainer is also placed in the water connection, which prevents sediment from choking the passage to valve. All valves are located at the bottom of feeder, and are consequently covered with water at all times.

Illustration, Fig. 184, shows the proper method of connecting any water feeder to a steam boiler. The lower pipe from feeder to bottom of boiler is to convey the water to the boiler, and the upper pipe from top of feeder to upper part of boiler is for the purpose of balancing the height of water in the feeder by allowing air to escape from the top of feeder and bringing the pressure of steam on top of water in the feeder, so that the line of water in feeder will correspond to that in the boiler. The upper boiler connection to feeder should in all cases be taken direct from the boiler at a point above the water line. It is also advisable in setting water feeders to provide both top and bottom connections with gate valves as shown, and also one brass union, so that the feeders can be repaired and disconnected without having to lower either the steam or water in boiler.

The By Pass for Boiler Connections.

Automatic water feeders attached to low pressure steam boilers should be provided with a by pass connection as shown at lower pipe connectings in

Fig. 184, so that in filling the boiler on the start it can be done in less time by passing direct to the boiler by opening lower valve from water supply pipe.

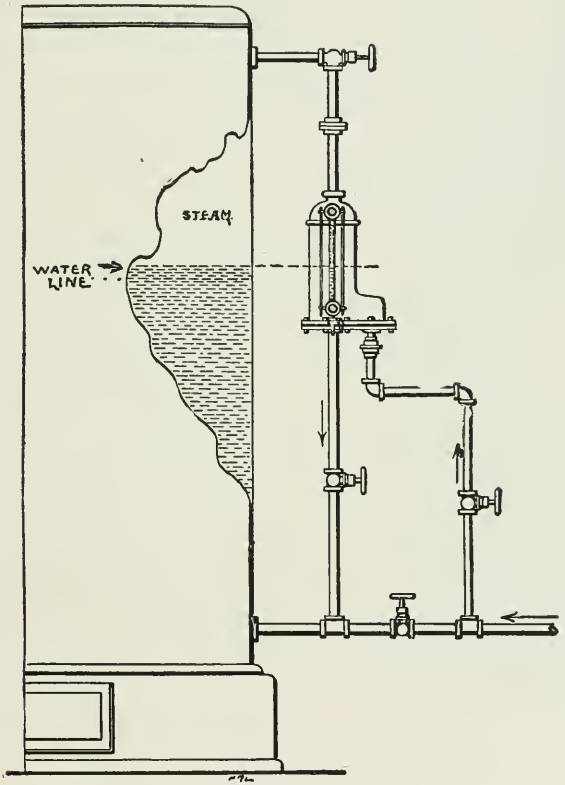


Fig. 184.

Automatic Device to Prevent Flooding of Low Pressure Steam Heating Boilers.

It is a well-known fact among practical steam-fitters that under certain conditions large quantities of water will leave the boiler for a time, lodging in some of the radiators or long runs of supply pipe, so that it becomes neces-

sary at such times to allow new water pass into the boiler in order to protect same from overheating, which as a rule takes place before there has been a complete circulation of steam through the heating system, and after there has been a thorough circulation through the heating apparatus, all water will have returned again to the boiler.

Fig. 185.

After what has taken place as stated above we will find more water in the boiler than is necessary, and should this surplus water be allowed to remain in the boiler for a few days, in many cases the boiler would be found flooded so that steam could not be generated.

To overcome this difficulty of flooding the boiler the device shown in Fig. 185 was devised. It consists of a combined water feeder and overflow, having two floats and two valves in a single casing; the valves are of the same construction, the only difference being that one is in a reverse position to the other, so that when the water rises above the desired line, the overflow valve is opened by the rising of one float, while the supply valve which admits the water to the feeder closes as the water rises to its proper height.

These machines as shown in Fig. 185 are also provided with glass gauges and answer as water column.

Another automatic device of recent construction for low pressure steam boilers is shown in Fig. 186. This is called an automatic water feeder and double alarm water column. It automatically supplies the boiler to which it may be attached with water. At the same time it is a complete water column, having glass gauge and try-cocks. It is also provided with a steam whistle, as may be noticed on top of column, which will sound an alarm should the water fall below a safe point in the boiler, and will also whistle should the water rise in the boiler above the desired height.

Vacuum Systems of Steam Heating.

The so-called vacuum systems as applied to steam heating plants consists chiefly in forming a suction on the air outlets or return connections of radiators by mechanical means, such as pumps with pistons, which may be operated by steam, water, or electricity. Siphon jets may be used to form

the necessary suction, which are also operated by steam and water. The pumps or ejections used on such work must operate continuously while heat is required. The object aimed at in such systems is to assist circulation of steam through the heating apparatus by preventing the atmospheric pressure from entering the pipes and radiators, so that when steam is allowed to pass into the supply pipes of the heating apparatus from a boiler or exhaust from an engine, it will flow rapidly to all parts or the radiation of such apparatus, on account of the partial vacuum formed therein by the suction of the pumps or ejections.

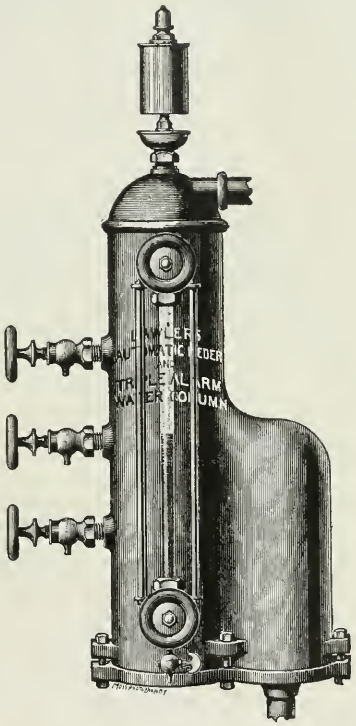


Fig. 186.

The construction of pipe-work and setting of radiators for these systems is the same as done for gravity return or pressure systems, with the exceptions of manner in which the air pipes are carried from radiators and connected to pumps, and the inserting of special valves in return connections.

The vacuum appliances are principally used in large steam heating plants, where there is pressure of steam sufficient to operate the pumps, and where exhaust steam is utilized for heating purposes, otherwise electric pumps would be necessary, which would materially add to the cost of producing the necessary suction.

As yet, little or nothing has been done in the way of so-called vacuum systems for ordinary dwelling-house heating. One of the most important features connected with these systems is to have a reliable thermostatic air valve, which is applied to each radiator, and which will be quick in action, closing by a low temperature of steam and opening again by the fall of two or three

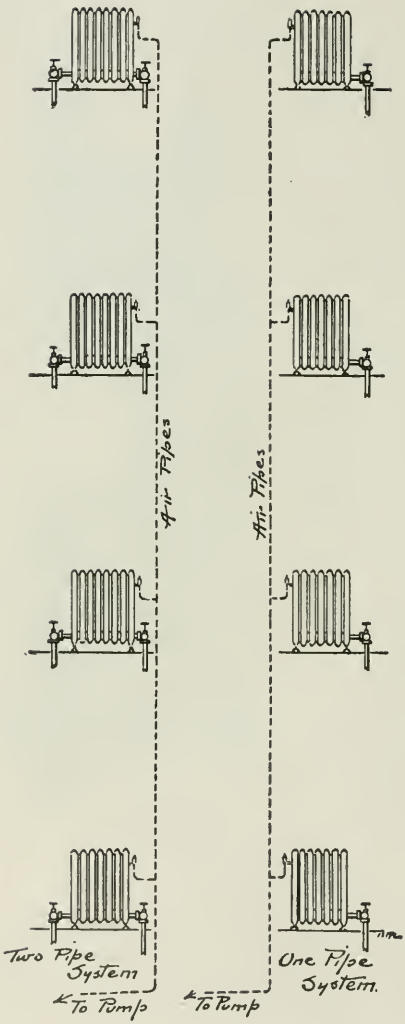


FIG. 187.

degrees. Such valves should be constructed on principles and of such materials that constant adjustment would not be necessary in order to have them operate in a satisfactory and economical manner. For vacuum systems the pipe-work of the entire heating plant should be absolutely air-tight, therefore it will require a much better class of work throughout for satisfactory results. The stuffing boxes of all valves on the heating system is usually a great source of annoyance, as air easily leaks through a loose valve stem.

SAND HOLES IN RADIATORS and other castings, and leaks from spongy iron, are also found to be a great source of trouble, although too small to be noticed by the leakage of steam, will allow large quantities of air to enter the system and destroy the partial vacuum, thus making it necessary, as stated before, to keep the suction or vacuum pumps in constant operation.

HOW THE SYSTEM OPERATES.

The air and part of the condensation is sucked or drawn from the various radiators through a system of pipes to a receiving chamber at a point below all radiation or near the boiler where the air is allowed to escape to the

atmosphere and the water of condensation pumped back again into the boiler or it may be allowed to escape into a waste pipe.

The one or the two pipe method of connecting radiators may be used as shown in illustration, Fig. 187, with some of the vacuum systems. The dotted lines in this illustration represent the air or suction pipes which are carried to the vacuum pump; these pipes may be connected together at convenient points with proper capacity for the amount of radiation on same, or the air lines may be carried separately to the suction pump.

Automatic Steam Traps and their Utility.

Automatic steam traps are used for the purpose of allowing condensation of steam to pass or escape from steam pipes without the loss of live steam, from such escapement.

Such devices are largely used on the return connections of steam heating coils, where steam is used for the purpose of heating water, and also on return connections from high pressure steam heating plants where the condensation does not return to the boiler by gravitation.

There are many constructions of steam traps to be found in the market, some operated by floats and others by the expansion and contraction of metal rods, bars, and tubes.

As the object of the steam trap is to remove water of condensation from steam pipes and at any temperature, it is easy to understand that the most reliable construction of device is those operating on the gravity principle, because it is gravity, and not temperature, with which they must contend. We therefore show some of the best makes of gravity steam traps that are to be found in any market.

The illustrations in Fig. 188 show the well-known Nason gravity steam trap which has stood the test of every class of work for many years and is known to the heating trade in general. The trap shown in Fig. 188 operates on what is known as the bucket principle, the float which opens and closes the valve is made in the form of a bucket which holds water, and is entirely open at top. This bucket is usually made of sheet copper, and it has attached to it a valve stem which passes up through a tube, the tube connecting to outlet at top of trap and extending down to a point near the bottom of the bucket. As the water of condensation flows from the radiating surface into the trap it fills the space on outside of bucket or float, which causes the float to rise and hold the valve closed for a time until water rises above the top of

bucket, when the water flows also into the bucket, and, filling same, the float loses its buoyancy power and then falls by its weight, which opens the valve to the outlet. The pressure of steam, being above the water, forces the water up the outlet tube from bottom of bucket, until the bucket is again about

NASON STEAM TRAPS.

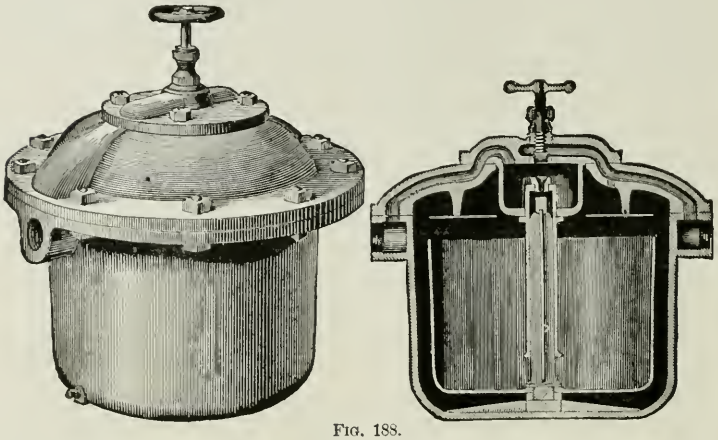


FIG. 188.

empty, when, with its buoyancy power, it rises and closes the outlet valve, thus repeating the action as fast as condensation accumulates. The simplicity of this construction has proved its great success.

The following table shows the number of square feet of heating surface in a common high pressure steam heating apparatus which steam traps of the several sizes may be expected to drain, under ordinary exposure to cooling. For very low pressure, either a large size should be used or a steam trap should be specially ordered, with enlarged valve opening.

Number of steam trap	1	2	3	4	5
Size of pipe connections....inches	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$
Diameter outside of flanges.... "	$10\frac{3}{4}$	$14\frac{1}{2}$	$15\frac{3}{4}$	19	$24\frac{1}{2}$
Diameter of cylinder.... "	8	$10\frac{1}{2}$	12	14	18
Height to top of valve.... "	11	14	$16\frac{1}{2}$	$18\frac{1}{2}$	$23\frac{1}{2}$
Height to top of cover.... "	8	10	12	14	$15\frac{1}{2}$
Maximum discharge pounds per minute....	2	5	8	12	20
Greatest number of square feet of surface to which it should be applied....	350	900	1400	2000	3500
Greatest lineal feet of one-inch pipe surface to which it should be applied....	1050	2700	4200	6000	10500

Services to Which they may be Applied.

For taking off the water of condensation from steam pipes and coils, and apparatus employed in steam heating.

For draining steam kettles, vacuum pans, marsh kettles, steam engine supply pipes, thus keeping cylinders free from water; evaporating pans, steam jackets on engines, steam jackets on pumps, stills in absorption ice machinery.

These traps are recommended for service on any arrangement that requires to draw off water of condensation while preserving condition of vacuum, evaporation, etc.

Kieley's Standard Steam Traps.

In the illustration, Fig. 189, we show another style of gravity steam trap which operates on the open float or bucket principle; but, as will be noticed by referring to the illustration, the float of this style trap is pivoted to the cap on one end, while the greater part of the float extends horizontally beyond the location of valve, thus giving the trap greater power to operate against high pressure.

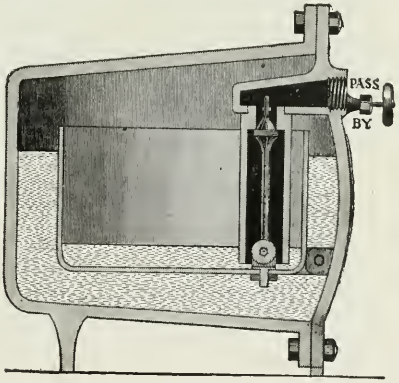


Fig. 189.

An important feature in the Kieley steam trap is that the valve and all movable parts are attached to the cap and may be removed without disturbing the main body of the trap. The construction of these traps is such as to enable them to work under a pressure ranging from 5 to 200 pounds per square inch.

The Kieley Standard Steam Traps are numbered from 1 to 7 and will drain from 4,000 to 50,000 lineal feet of one-inch pipe as per table below.

Size.....Number	¾	1	1¼	1½	2	2½	3
Size, inlet.....Inches.	¾	1	1¼	1½	2	2½	3
Size, outlet	4,000	6,000	10,000	15,000	25,000	35,000	50,000
No. lineal ft. one-inch pipe will drain.	1	2	3	4	5	6	7

Kieley's Low Pressure Balanced Valve Steam Trap.

This trap is a *fac-simile* of the standard trap shown in Fig. 189, with the exception of the valve controlled by the float.

By examining the cut it will be seen that the valve controlled by the float is double seated or balanced, giving an area equal to the pipe connection.

It is due to the great area afforded by the valve that this trap is especially adapted for draining the condensation from feed-water-heaters, where condensation takes place very rapidly under a very low pressure, and where large quantities of water must be discharged in the shortest possible time in order to prevent the exhaust steam from carrying it to the roof or other undesirable place.

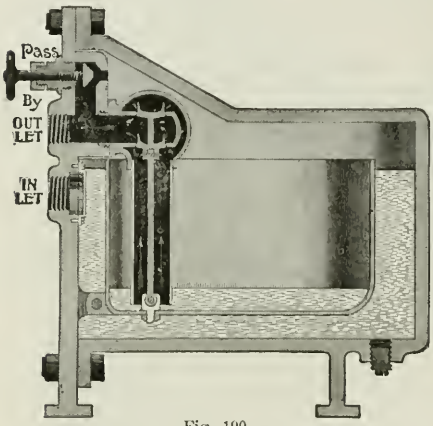


Fig. 190.

The float in this trap is as durable as it is possible to make a float and non-collapsing, owing to the fact that it is an open one. The float being pivoted on one end and the valve stem being fastened near the pivoted end, the opening and closing power of the float acts on the valve the same as the lever, enabling it to open and close a much larger valve than it could were the valve stem fastened to the center of the float as in the case with most open float traps.

The "pass-by" in this trap is the same as in the Standard Trap, through which the air, and, if desirable, the water, can be discharged independent of the valve controlled by the float, thereby saving the otherwise necessary pipe, valves and fittings to make an independent pass-by.

Steam Traps Operated by Closed Floats.

There are many modifications of traps in the market in which the motive power to open the valve for the escapement of condensation, is that obtained

by the buoyancy of hollow copper floats, which floats are fixed to one end of a lever, while the escapement valve is pivoted to said lever at a short distance from the opposite end of same.

In traps of this construction it is important, in order to obtain the greatest power for the work to be performed, to so construct the float that it will be as light as possible, because the less weight there is in such a float the greater will be its buoyancy or lifting power. The most power that can be obtained from such floats will be the difference between the entire weight of the float and the specific weight of water displaced by the entire area of the float. It will therefore be seen that for any considerable power the float must be of a considerable size, and as the size of such floats increase they also become weaker in proportion, and unless constructed of proper metal will collapse under heavy exterior pressure. Yet notwithstanding these points in closed float traps, there are a few that have proved very satisfactory for many years.

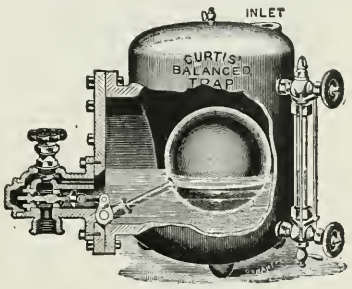


Fig 191.

The Curtis Balanced Steam Trap.

In the illustration, Fig. 191, we show a well-known make of trap which has a large capacity for the space it occupies when set. This trap is fitted with a balanced valve which can be moved with little power, and is provided with by pass valves, all of which are united to a cap on the side which can be be removed in case of repairs without disturbing the main body of trap.

The Daniels' Steam Trap.

Another steam trap of the hollow float type is shown in Fig. 192, which has embodied in it some novel features that should be of interest to practical steam users and fitters. In this make of trap, like some of the others just described, all moving parts are attached to the cover, and may be removed without not only disturbing the main body of same, but without breaking either the inlet or outlet connections of the trap. A special feature in this trap, shown in Fig. 192, lies in the manner in which the weight of the float is

compensated for, thus leaving the entire area of float as buoyancy power to open the valve against the interior pressure of steam and condensation.

As will be noticed by referring to Fig. 192, the lever which is operated by the float is provided with a balance weight marked at A on opposite end of lever to that of the float, while the lever is pivoted to cover between the float and weight, and whatever weight there might be in the float it is balanced by weight A, with the exception of just enough to allow the valve to fall and close after the water of condensation has been discharged sufficiently to allow the float to fall, thus making it possible to construct the float of heavy metal which will be necessary to resist the heavy internal pressure, or to operate the valve by a comparatively small float.

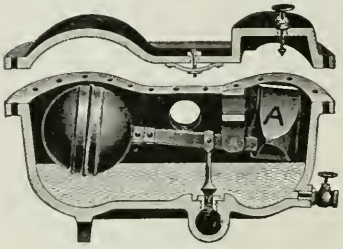


Fig. 192.

Automatic Return Steam Traps.

The object of return steam traps is to return water of condensation to the boiler from which the steam is generated and carried at a high pressure without the use of pumps or injections. And where such return traps are used, it is necessary to carry a sufficient pressure of steam on the radiating surface to lift a column of water as high as the distance in height between the receiving chamber for condensation from radiation, and the top of return trap, which is usually located at a point above the boiler. It will therefore be necessary to carry from 20 to 30 pounds pressure of steam at all times on the radiation which is drained and returned to the boiler in this manner.

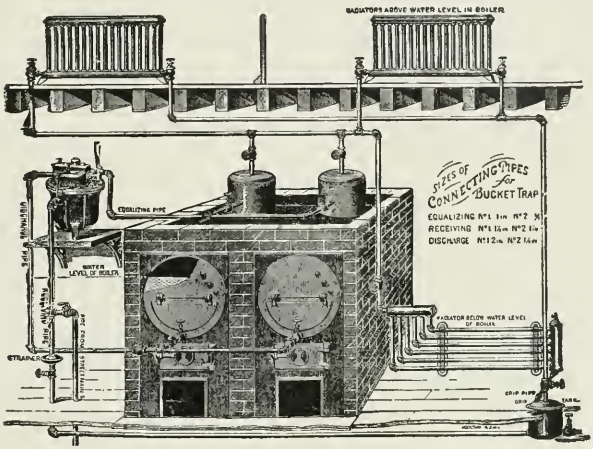
The Pratt Automatic Return Steam Trap.

Like almost all steam appliances, there are a large number of return traps of various modifications, yet all of which operate on the same general principle. And for the purpose of explaining the manner in which such devices operate we make use of Fig. 193, which shows a well-known make completely set, and which is known as the Pratt Return Steam Trap.

Operation is as Follows:

All water of condensation is conveyed to a receiving tank which, in the illustration, Fig. 193, is marked R, is provided with a stand pipe which ex-

tends down within an inch or so from bottom of tank as indicated by dotted lines, condensation is forced up this stand pipe by the pressure of steam on the radiating surface delivering the water into the top of trap which is located


RADIATORS ABOVE WATER LEVEL IN BOILER
SIZES OF CONNECTING PIPES FOR BUCKET TRAP
EQUALIZING N°1 1in N°2 ¾
RECEIVING N°1 1½in N°2 1in
DISCHARGE N°1 2in N°2 1½in
EQUALIZING PIPE
WATER LEVEL OF BOILER
RADIATOR BELOW WATER LEVEL OF BOILER
STRAINER

In this cut is presented the Albany Return Trap, and a plan of heating coils without reference to size or style, but merely for the purpose of showing the trap in connection with boilers and coils.

Bottom of trap should set about three feet or more above water line in boiler.

Fig. 193.

above the boiler. This pipe between tank and trap, as will be noticed, is provided with a check valve near the trap set in a horizontal position, which is the best way to set such valves. It will also be noticed that the trap is provided with two pipe connections to the boiler, one from bottom of trap to lower part of boiler, and the other from top of trap to top of boiler. The return pipe from trap to bottom of boiler is also provided with a check valve

as may be noticed directly under trap, while the upper pipe or steam connection to trap is provided with a valve which is operated by the rise and fall of a float in the trap. As water flows into the trap the float rises, and at a certain point moves the lever, which extends from the side of trap a sufficient distance to open the supply of steam from top of boiler, and as the check valve under the trap opens to the boiler, the water, by its weight having the pressure of steam above it, falls and is discharged from the trap to the boiler. As the water lowers in the trap the float also drops and again closes the supply of steam to top of trap, and as the check valve in pipe below trap prevents water returning from boiler, and the steam supply from boiler is closed to the trap, water of condensation again flows from receiver R, thus operating automatically without requiring the slightest attention.

A steam trap constructed on entirely different principles to any so far described, and which has a very large range of utility as it can be used under so many different conditions is known to the heating trade as the Bundy Return Steam Trap.

The Bundy Return Steam Trap will return to the boiler the condensed water from all apparatus using live or exhaust steam for power, heating, drying, cooking, or other purposes. The trap is placed over the boiler at least three feet above the water line, with a direct connection to a receiver, as shown in the cut Fig. 194. When returning condensation from apparatus using live steam, sufficient pressure must always be carried to raise the water into the trap, as the trap is open to the atmosphere and consequently has no power to draw the water up to itself. The Bundy Return Trap does not create a vacuum; therefore a pressure above atmosphere is always required to raise the water to the trap.

To estimate this pressure, measure the distance from the lowest point of supply to the trap in a vertical line and figure one-pound pressure for each two feet of elevation. This is approximately correct and is based on the fact that a column of water 28 inches high, with a cross-section of one square inch, weighs one pound; but there are many cases where one-pound pressure for each two feet lift would not be sufficient, because of excessive friction due to the angles of the return pipes, valves, elbows, etc., which must be overcome in delivering the water to the trap, so due judgment must be exercised when installing traps under such conditions. It is wise to be fairly liberal in these calculations in any event, as the operation of all Bundy Return Traps

is accelerated or retarded in proportion to the pressure, or head, on the water that is being delivered to the trap. With a strong pressure the bowl will fill more quickly, and the number of operations will be increased, while with a sluggish movement of the water it will take longer to fill the bowl, the number of operations will be decreased, as also the quantity of water delivered.

As a Lifting Pump.

The Bundy Return Steam Trap can also be used in place of a steam pump for lifting water from a low to a higher level, discharging into a tank, heater, or the atmosphere; it will discharge against any pressure which is less than the pressure of the live steam operating the trap, which provides the force for elevating the water.

As a Boiler Feeder.

The Bundy Return Steam Trap can also be used as an initial boiler feeder in place of a steam pump, receiving the water from the feed water heater and discharging it into the boiler, or boilers, at regular intervals, thus constituting a *gravity feed apparatus* both satisfactory and economical in results.

Among the many advantages of the Bundy Return Steam Trap, when acting as a boiler feeder, is that of minimum expense for maintenance and repairs. In the former there are no suction or discharge valves to be kept in order, no springs to lose their elasticity, and no pistons to be packed. The trap is practically a frictionless machine. There is a very slight travel on the trunnions which support the bowl. The stuffing box nuts do not travel at each discharge of the trap a quarter of a turn. Consequently it can readily be appreciated that the item of wear and tear is so infinitesimally small as to be incalculable. The Bundy Return Trap will receive the water from the feed water heater at practically the boiling point, and as this water comes into direct contact with the live steam that enters the trap bowl, it absorbs the latent heat units contained

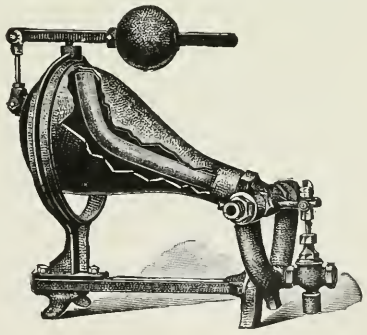


Fig. 194.

by the steam, and there is an appreciable gain instead of a loss. The trap is not intended to handle water at less than 100 degrees temperature.

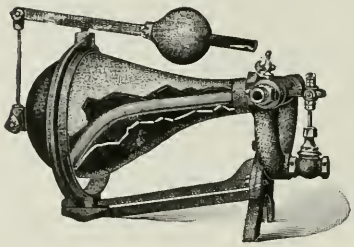


Fig. 195.

The above illustration is an interior view of the Bundy Return Steam Trap, showing equalizing pipe.

The live steam enters the trap through this pipe and is discharged on the surface of the water which the bowl contains. This equalizes the pressure on the trap and the boiler, and the water passes out through the same opening by which it entered and into the boiler by gravity.

In the accompanying illustration, Fig. 195, we give an interior view of the Bundy Separating or Tank Steam Trap showing the inverted pipe, the end of which is immersed in the water forming a seal at the bottom; this effectually prevents the escape of the steam, but allows all the water to be discharged, elevating this water two feet for each pound of pressure carried on the apparatus that is being drained. The water enters the trap through an opening in the trunnion neck, but when leaving the trap it passes out through the pipe and discharge valve.

Bundy Return Steam Trap as Used on Vacuum Systems.

The Bundy Return Steam Trap will successfully remove condensation from apparatus working under a vacuum. The connections are made as shown in the above plan. Live steam is supplied for discharging the trap and elevating the contents to any desired height. This connection may be taken from any conveniently located supply line and not necessarily direct from the boiler.

The supply of live steam can be regulated by a throttle valve placed in the pipe conveying the steam to the trap, as the pressure should not be in excess of that actually required to force the condensation out of the bowl and elevate the same to the final point of outlet. A quarter turn of the valve wheel will usually admit all the steam needed for the operation of the trap.

The check valves in this system must be perfectly tight in order to preserve the vacuum. In many steam heating plants there are different pressures;

there may be 30 pounds on one apparatus and 50 pounds on another. It would not be good practise to connect the returns from these two pressures into one receiver, or direct into the same return trap, without making provision to neutralize the pressures; for without this the high pressure would back up the condensation in the line of piping carrying the lower pressure and hold it there. This is overcome by attaching a separate steam trap to each return pipe, and connecting the discharge from these traps into the receiver. These traps discharge the condensation, but allow no steam to get through, thus putting both lines on a "Low Pressure" Basis.

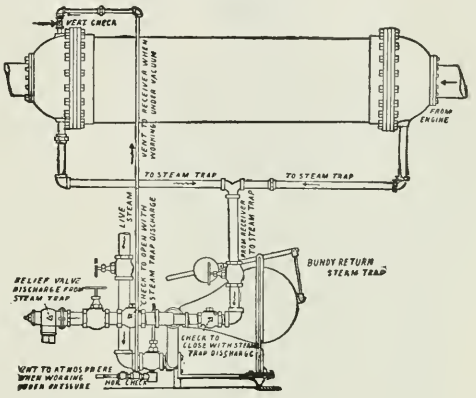

VENT CHECK
VENT TO RECEIVER WHEN WORKING UNDER VACUUM
FROM ENGINE
TO STEAM TRAP
TO STEAM TRAP
LIVE STEAM
CHECK TO OPEN WITH STEAM TRAP DISCHARGE
VENT RECEIVER TO STEAM TRAP
BUNDY RETURN STEAM TRAP
RELIEF VALVE DISCHARGE FROM STEAM TRAP
CHECK TO CLOSE WITH STEAM TRAP DISCHARGE
VENT TO ATMOSPHERE WHEN WORKING UNDER PRESSURE
HOR. CHECK

Fig. 196.

The same practise applies for any number of returns. By this plan the condensation is collected from many different pressures and all delivered to the boiler through one return trap. Experience has taught that even though the initial pressure of the steam supplied to the various types of heating apparatus is the same, the ratio of condensation will vary under certain conditions. This will have the effect of creating inconstant pressures and cause what is known in engineering parlance as short circuiting of the steam, when more than one return pipe connects into a receiver or header with the results as explained above. This is particularly true in plants where sudden changes of temperature take place in the steam using apparatus by the application of cold or wet material, causing the steam to condense very rapidly in one apparatus, while the others remain normal.

Bundy Single Return Trap System (Operation).

When returning condensation from different sources the returns should drain into one common reciveer as shown in the cut, Fig. 197. The receiver

has a pipe extending down the center, nearly to the bottom as illustrated by the white dotted lines; a water seal is formed which prevents the steam from entering the vertical pipe leading to the trap, and utilizes the full pressure on the returns to raise the water into the trap.

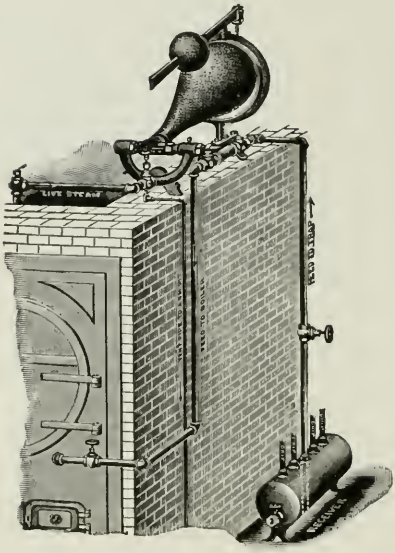


Fig. 197.

The operation of the trap is as follows:

The water to be delivered to the boiler passes through the check valve marked A into the receiving bowl.

The bowl swinging on the trunnions moves in a vertical travel. When empty it touches the top of the circular frame, but when filled with water to a point where its weight combined with that of the water, it overbalances the ball on the lever that extends longitudinally above the trap. This causes the bowl to sink to a lower level. There are two sets of lock-nuts on the valve stem, with room between them for the travel of a ring or sleeve which surrounds the valve stem, held in place by two set screws, the whole being fitted to the head piece that screws into the neck of the bowl. When the bowl sinks, the ring rises and engages the upper set of lock-nuts, pulling up on the valve stem. This raises the valve-disk of valve C from its seat, opens the valve, admits live steam to the trap bowl and closes the air valve. The live steam is taken direct from the boiler, and with the pressure on the trap and the boiler equal, the water drops by gravity from the trap into the boiler, passing through check valve B. The trap is always set three feet or more above the water line of the boiler. The bowl, now being empty, is raised to its former position by the ball-weight. The ring surrounding the valve stem engages the lower set of lock-nuts on its downward travel, and closes the steam valve,

at the same time opening the air valve, and venting the trap. Check valve A prevents the live steam from blowing through into the heating system while the trap is discharging, and check valve B prevents the water in the boiler from passing through, while the trap is filling.

Returning Condensation to Boilers Automatically by the Use of Pumps.

In exhaust steam heating plants the pressure carried on the radiating surface must be as low as possible, and to return the condensation to the boiler from such radiation, pumps are frequently used and which are automatically operated, by systems called pump governors. This consists in part of a receiving tank which is provided with a float, the float being attached by a system of levers to a steam valve. All condensation from the heating system flows to the receiving tank, and when filled automatically opens the steam supply valve to the pump, which sets the pump in motion. The pump being in motion takes its suction from bottom of pump governor, and delivers its water into the boiler against any pressure.

When the pump has drawn most of the water of condensation from the receiving cylinder, the steam to pump is automatically turned off again.

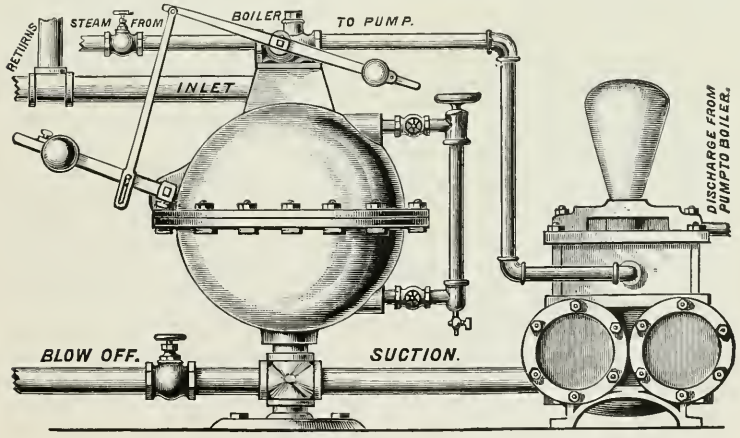


Fig. 198.

The Illustration, Fig. 194, shows Kieley's positive acting pump governor, for automatically returning condensation to boilers, especially where a low pressure is carried, or exhaust used for heating purposes.

This governor will govern the speed of the pump so that it will always be in exact proportion to the amount of condensation to be returned; or, in other words, when the condensation increases, the speed of the pump is increased proportionately, and as condensation decreases, a proportionate decrease in the speed of the pump takes place, thereby preventing all chances of the pump "running off," and at the same time insuring a good circulation in the heating apparatus and the proper return of the condensation under the highest possible temperature.

By using this governor in connection with a pressure regulating valve, exhaust steam from the engine and pumps can be utilized for heating the building; if the exhaust is not sufficient, the regulating valve will automatically allow as much live steam to pass into the heating main as is necessary to keep up the desired pressure.

Number	1	2	3
Drainage capacity, Feet of one inch pipe	15,000	50,000	100,000
Steam pipe.....Inches	¾	1	1½
Suction..... "	1½	2½	3

Referring to the illustration, Fig. 198, it will be seen that the arrangement of this apparatus is so simple, that it can be easily and quickly set by any steam fitter of average intelligence.

Back Pressure Valves and their Utility.

In steam heating plants where exhaust steam is utilized, it is necessary in most systems to carry a pressure of some degree on the radiation, while at the same time it is quite objectionable to carry much pressure which would be a resistance to the engine (as stated on another page) from which the exhaust steam is taken, we therefore place on the exhaust pipe, what is known as a back pressure valve, which in a measure is something similar to that of a check valve. But in place of preventing the steam going through the pipe in a backward direction, it is for the purpose of checking the flow of steam in its forward direction. Hence the back pressure valve is also in a measure similar to that of a pressure regulating valve.

The back pressure valve is therefore necessary on exhaust heating plants, and of this device it can be said that not every make that has been placed on the market has given entire satisfaction. And this is not to be wondered at,

because the conditions under which such valves are expected to work are severe.

The steam, as it passes through the pipes in an intermittent motion according to the strokes of the engine, keeps the back pressure valve in constant vibration, and a special source of annoyance from such valves has been the disagreeable and unbearable noise produced as the movable part of valve comes in contact with its seat at every pulsation of the steam.

Those who have been making back pressure valves for years, all claim to have overcome the objectionable features mentioned above. We show in the following illustrations some of the most prominent back pressure valves in the market.

The Kieley Back Pressure Valve.

In the Kieley back pressure valve there is a double passage-way for the flow of steam, the object of which is to assist the lever and weight in balancing the movable part of valve, and which makes it possible to operate a valve of large area with a comparatively small sized weight and short lever. Because the pressure of steam with the valve closed, is exerted on the area of lower outlet, which tends to keep the valve closed, while the pressure of steam is also exerted on the area of upper outlet which has a tendency to open the valve, and the upper area being the largest, the weight shown above on stem is necessary to overbalance this additional upper area and also provide, for whatever pressure that may be necessary to carry in the heating system. The body of this valve is made large to give a free and easy flow of exhaust steam through it when

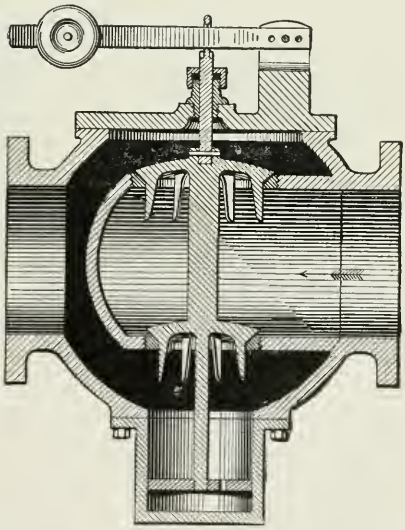


Fig. 199.

open, as will be noticed by referring to illustration, Fig. 199. Provision is made in this valve to prevent noise in the seating of the valve, which consists of a cushioning cylinder as may be noticed located on lower part of valve. This cushioning cylinder is nicely fitted with a plunger secured to the valve stem proper, and which makes it impossible for the valve to be quickly seated, thus preventing noise and at the same time protecting the seats of the valve from hard usage. It should be of interest to the mechanic to notice the various modifications of mechanical devices constructed to perform the same work or produce the same results. It is a proof that there are many ways of doing any one thing.

The illustration, Fig. 196, is a sectional view, showing the interior arrangement of the excelsior back pressure valve which is being manufactured by Jenkins Bros. A special feature in this valve is that when not in use doing

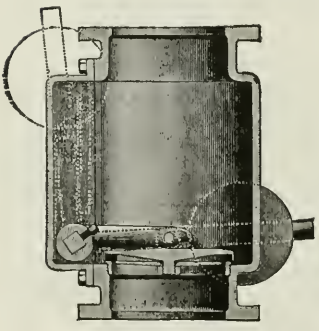


FIG. 200.

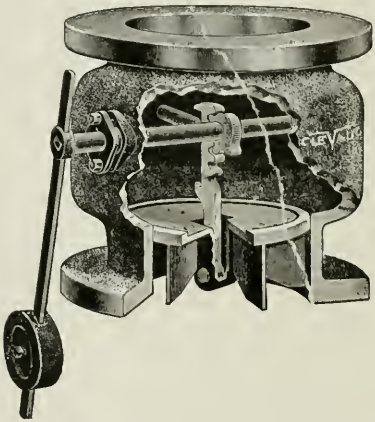


FIG. 201.

back pressure service the valve can be quickly thrown to one side of the body, leaving the full clear area of the pipe for exhaust steam to escape. The Jenkins back pressure valve can also be set in any position with the same results, and the seat of this valve is fitted with the well-known Jenkins special material used in steam valve work, which prevents noise as the valve closes. The makers of this valve claim an advantage in being able to remove the interior parts, with little trouble for examination or repairs.

The Clevaue Back Pressure Valve.

Another valve having excellent points of construction is shown in illustration, Fig. 201, and is known in the trade as the Clevic. As will be noticed the valve proper, is constructed in the form of a piston and is not seated, therefore when closing cannot strike anything in cutting off the steam whereby a noise could be produced; at the same time a very little rise to the plunger gives large area for the escapement of exhaust steam.

This back pressure valve can also be set in any position, vertical or horizontal, as shown in illustration, Fig. 202.

The valve shown in Fig. 202 does not take up much space in the line of pipe compared with its diameter, which is often a desirable thing in close places; it can also be set wide open with little trouble when not wanted for back pressure purposes. This article on back pressure valves, is for the purpose of pointing out to those not fully acquainted with such devices not only the utility of such valves, but to show that such devices can be constructed that will operate successfully without noise.

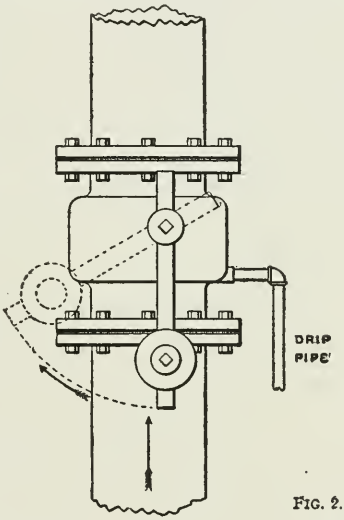


Fig. 2.

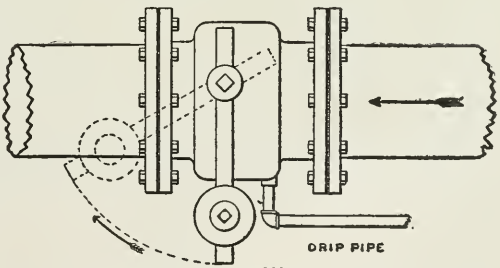


Fig. 202.

CIRCUMFERENCES, AREAS, SQUARES, CUBES, SQUARE AND CUBE ROOTS, 1 TO 80.

Diam. or No.	Circumference.	Area	Square.	Cube.	Square Root.	Cube Root.	Diam. or No.	Circumference.	Area.	Square	Cube.	Square Root.	Cube Root.
1	3.14	.7854	1.	1.	1.	1.	41	128.8	1320.3	1681	68921.	6.403	3.448
2	6.28	3.142	4.	8.	1.414	1.260	42	131.9	1385.4	1764	74088.	6.481	3.476
3	9.42	7.069	9.	27.	1.732	1.442	43	135.1	1452.2	1849	79507.	6.557	3.503
4	12.56	12.57	16.	64.	2.	1.587	44	138.2	1520.5	1936	85184.	6.633	3.530
5	15.70	19.63	25.	125.	2.236	1.710	45	141.4	1590.4	2025	91125.	6.708	3.577
6	18.84	28.27	36.	216.	2.449	1.817	46	144.5	1661.9	2116.	97336.	6.782	3.583
7	21.99	38.48	49.	343.	2.646	1.913	47	147.7	1734.9	2209.	103823.	6.856	3.609
8	25.13	50.27	64.	512.	2.828	2.	48	150.8	1809.6	2304.	110592.	6.928	3.634
9	28.27	63.62	81.	729.	3.	2.080	49	153.9	1885.7	2401.	119649.	7.	3.659
10	31.41	78.54	100.	1000.	3.162	2.154	50	157.1	1963.5	2500.	125000.	7.071	3.684
11	34.55	95.03	121.	1331.	3.317	2.224	51	160.2	2042.8	2601.	132651.	7.141	3.708
12	37.69	113.0	144.	1728.	3.462	2.289	52	164.4	2123.7	2704.	140608.	7.211	3.733
13	40.84	132.7	169.	2197.	3.606	2.351	53	166.5	2206.2	2809.	148877.	7.280	3.756
14	43.98	153.9	196.	2744.	3 742	2.410	54	169.6	2290.2	2916.	157464.	7.348	3.780
15	47.12	176.7	225.	3375.	3.873	2.466	55	172.8	2375.8	3025.	166375.	7.416	3.803
16	50.26	201.0	256.	4096.	4.	2.520	56	175.9	2463.0	3136.	175616.	7.483	3.826
17	53.40	226.9	289.	4913.	4.123	2.571	57	179.1	2551.8	3249.	185193.	7.550	3.849
18	56.54	254.4	324.	5832.	4.243	2.621	58	182.2	2642.1	3364.	195112.	7.616	3.871
19	59.69	283.5	361.	6859.	4.359	2.668	59	185.4	2734.0	3481.	205379.	7.681	3.893
20	62.83	314.1	400.	8000.	4.472	2.714	60	188.5	2827.4	3600.	216000.	7.746	3.915
21	65.97	346.3	441.	9261.	4.583	2.759	61	191.6	2922.5	3721.	226981.	7.810	3.937
22	69.11	380.1	484.	10648.	4.690	2.802	62	194.8	3019.1	3844.	238328.	7.874	3.958
23	72.25	415.4	529.	12167.	4.796	2.844	63	197.9	3117.3	3969.	250047.	7.937	3.979
24	75.39	452.3	576.	13824.	4.899	2.885	64	201.1	3217.0	4096.	262144.	8.	4.
25	78.54	490.8	625.	15625.	5.	2.924	65	204.2	3318.3	4225.	274625.	8.062	4.021
26	81.68	530.9	676.	17576.	5.099	2.963	66	207.3	3421.2	4356.	287496.	8.124	4.041
27	84.82	572.5	729.	19683.	5.196	3.	67	210.5	3525.7	4489.	300763.	8.185	4.061
28	87.96	615.7	784.	21952.	5.292	3.037	68	213.6	3631.7	4624.	314432.	8.246	4.082
29	91.10	660.5	841.	24389.	5.385	3.072	69	216.8	3739.3	4761.	328509.	8.307	4.102
30	94.24	706.8	900.	27000.	5.477	3.107	70	219.9	3848.5	4900.	343000.	8.367	4.121
31	97.39	754.8	961.	29791.	5.568	3.141	71	223.1	3959.2	5041.	357911.	8.426	4.141
32	100.5	804.2	1024.	32768.	5.657	3.175	72	226.2	4071.5	5184.	373248.	8.485	4.160
33	103.7	855.3	1089.	35937.	5.745	3.208	73	228.3	4185.4	5329.	389017.	8.544	4.179
34	106.8	907.0	1156.	39304.	5.831	3.240	74	232.5	4300.8	5476.	405224.	8.602	4.198
35	110.	962.1	1225.	42875.	5.916	3.271	75	235.6	4417.9	5625.	421875.	8.660	4.217
36	113.1	1017.9	1296.	46656.	6.	3.302	76	238.8	4536.5	5776.	438976.	8.718	4.236
37	116.2	1075.2	1369.	50653.	6.083	3.332	77	241.9	4656.6	5929.	465533.	8.775	4.254
38	119.4	1134.1	1444.	54872.	6.164	3.362	78	245.0	4778.4	6084.	474552.	8.832	4.273
39	122.5	1194.6	1521.	59319.	6.245	3.391	79	248.2	4901.7	6241.	493039.	8.888	4.291
40	125.7	1256.6	1600.	64000.	6.325	3.420	80	251.3	5026.6	6400.	512000.	8.944	4.309

Average Annual Temperature in United States.

Place of Observation.	Average Temperature.	Place of Observation.	Average Temperature.
Tucson, Arizona	69	Salt Lake City, Utah	52
Jacksonville, Florida	69	Romney, West Virginia	52
New Orleans, Louisiana	69	Indianapolis, Indiana	51
Austin, Texas	67	Leavenworth, Kansas	51
Mobile, Alabama	66	Santa Fé, New Mexico Ter	51
Jackson, Mississippi	64	Sterlacoom, W. Ter	51
Little Rock, Arkansas	63	Hartford, Connecticut	50
Columbia, S. Carolina	62	Springfield, Illinois	50
Ft. Gibson, Indian Ter	60	Camp Scott, Nevada	50
Raleigh, N. Carolina	59	DeMoines, Iowa	49
Atlanta, Georgia	58	Omaha, Nebraska	49
Nashville, Tennessee	58	Denver, Colorado	48
Richmond, Virginia	57	Boston, Massachusetts	48
Louisville, Kentucky	56	Albany, New York	48
San Francisco, California	55	Providence, Rhode Island	48
Washington, D. C	55	Detroit, Michigan	47
St. Louis, Missouri	55	Ft. Randall, Dakota Ter	47
Baltimore, Maryland	54	Sitka, Alaska	46
Harrisburg, Pennsylvania	54	Concord, New Hampshire	46
Wilmington, Delaware	53	Augusta, Maine	45
Trenton, New Jersey	53	Madison, Wisconsin	45
Columbus, Ohio	53	Helena, Montana Ter	43
Portland, Oregon	53	Montpelier, Vermont	43
Ft. Boise, Idaho	52	St. Paul, Minnesota	42

Heat and Cold—Degrees to Freeze, Melt and Boil.

Degrees of Heat Above Zero at which the following articles melt.

Antimony	950	Gutta Percha	150
Brass	1,900	Lead	500
Bismuth	476	Lard	96
Copper	2,160	Silver	1,850
Cast Iron	3,500	Tin	420
Gold	1,983	Zinc	740
Glass	2,400	Ice	35

Degrees of Cold Above Zero at which the following articles Freeze.

Strong Wine	20	Milk	29
Turpentine (Spirits)	15	Water	32

Degrees of Heat Above Zero at which the following articles Boil.

Quicksilver	630	Petroleum	305
Linseed Oil	600	Water	210
Alcohol	175	Blood Heat	98

Weight of a Cubic Foot of Earth, Stone, Metal, Etc.

Article.	Lbs.	Article.	Lbs.
Alcohol	49	Lead, cast	709
Ash Wood	53	Lead, rolled	711
Bay Wood	51	Milk	64
Brass, gun metal	543	Maple	47
Brandy	58	Mortar	110
Beer	65	Mud	102
Blood	66	Marble, Italian	169
Brick, common	102	Marble, Vermont	165
Cork	15	Mahogany	66
Cedar	35	Oak, Canadian	54

Weight of a Cubic Foot of Earth, Stone, Metal, Etc.—*Continued.*

Article.	Lbs.
Copper, cast	547
Copper, plates	543
Clay	120
Coal, Lehigh	56
Coal, Lackawanna	50
Cider	64
Chestnut	38
Ebony	83
Earth, loose	94
Glass, Window	165
Gold	1,203¾
Hickory, pig-nut	49
Hickory, shell-bark	43
Hay, bale	9
Hay, pressed	25
Honey	90
Iron, cast	450
Iron, plates	481
Iron, wrought bars	486
Ice	57¼
Lignum Vitæ Wood	83
Logwood	57
Oak, live, seasoned	67
Oak, white, dry	54
Oil, linseed	59
Pine, yellow	34
Pine, white	34
Pine, red	37
Pine, well seasoned	30
Platina	1,219
Red Hickory	52
Silver	625¾
Steel, plates	487¾
Steel, soft	489
Stone, common, about	158
Sand, wet, about	128
Spruce	31
Tin	455
Tar	63
Vinegar	67
Water, salt	64
Water, rain	62
Window	36
Zinc, cast	428

EXHAUST STEAM HEATING.

Exhaust steam is now largely used for the heating of water, and warming of buildings, and it is the exception where a steam power plant is found allowing the exhaust steam to escape directly from the engines to the atmosphere. In buildings where steam engines are in constant operation, there will be generally found a sufficient amount of heat escaping from such engines known as exhaust or waste steam, to not only warm the feed water to such boilers up to a high temperature; but to warm the entire buildings in which such power boilers may be located to a temperature of 70° in cold weather. It will therefore be seen that the question of heating by exhaust steam is an important one; as every unit of heat saved in this way over the old extravagant method of allowing all exhaust steam escape from the engines without being further utilized, means a certain amount of money saved for the owner of an exhaust steam heating plant.

The Amount of Direct Radiation that can be Heated by Exhaust Steam.

In calculating the heating capacity of an engine from its exhaust steam, there will be some difference in the make or style of such engine from which the exhaust steam is taken, and the better the engine the less will be the heating capacity per horse-power of such engine from its exhaust steam; at the same time it will be a safe plan, based on practical experience, to allow from 125 to 150 feet of direct radiation per horse-power of engine from which the exhaust steam is taken. Condensing engines, of course, not being considered for such purposes. In exhaust steam heating plants where the feed water is heated by the exhaust steam, much of the heat from the exhaust steam will be extracted from the exhaust system by the feed water; and therefore this must be taken into consideration.

With a modern exhaust steam heating system there is very little waste of water, and practically no waste of steam in winter time where such plants are properly balanced. The water of condensation is all carried back from the radiation and from all other points where condensation accumulates to a common receiver from which it is pumped back to the boiler, and the only loss therefore will be through whatever may escape through the exhaust pipe

at times when the radiation is not in full operation. In large office buildings, hotels, and institutions, where the radiation is much more than can be supplied in cold weather by the exhaust steam, at such times and places there will be practically no loss of water or steam, because all exhaust steam is condensed by the radiation, and therefore cannot escape. Exhaust steam heating plants are always supplied with a live steam connection, which is controlled by a regulating valve, set so that, should the exhaust steam be insufficient to fill the heating plant, the regulating valve will open and allow live steam to pass into the heating system with the exhaust steam. The exhaust pipe in such systems are fitted with back pressure valves, which are usually set at about two pounds pressure, and as much less as the heating plant will successfully operate under. Therefore, should the engine stop at any time which would cut off the supply of exhaust steam to the heating plant, it will make no perceptible difference, as the pressure regulating valve on the live steam connection will open and keep the system filled with steam to the same pressure.

Oil a Detriment to Boilers and Heating Pipes.

It is found that where oil or grease is allowed to mingle with the water in a steam boiler, the life of such a boiler will be shortened very much, for the reason that heavy lubricating oils mix with such sediment as may be in the water and form into a hard substance, which unites to the interior surface of the boiler, and which not only corrodes the iron on the inside, but keeps the water from such surface to a more or less extent and allows the exterior part of such surface to burn by the action of the fire.

Oil is also objectionable when allowed to pass with the steam into the heating pipes and radiators of a heating plant, because such pipes are easily clogged up with oil and grease. Therefore the modern exhaust heating plant is equipped with a device called a grease or oil extractor, which separates the oil from the steam and condensation, allowing only pure water to pass into the boiler, and pure steam to pass into the heating plant, and at the same time saving the oil thus extracted, which is filtered and used over again. Engines must be lubricated, and large quantities of oil pass into the cylinders, according to the size of the engines, all of which must mingle with the exhaust steam. It will therefore be seen that a good oil extractor is a most important thing to have on any kind of steam engine, as it will not only protect the

boiler from the corroding effects of the oil, but save in the consumption of the oil, and pay for itself in a very short time.

Pipe System for Exhaust Steam Heating.

The general arrangement of supply and return pipes as well as connections to radiation, will be the same for exhaust steam heating as used by the gravity low pressure system, but unless operated by some vacuum system the pipes should be one size larger, in order to secure a good circulation through the entire heating system under from one to two pounds pressure of steam.

The most satisfactory results are obtained in exhaust heating plants when operated on the vacuum principle, because there will be no back pressure on the engines, at any time, but often a partial vacuum in the heating apparatus which assists the engine in its work. It will therefore be seen that, although the pressure will be less in a heating plant operated under the vacuum principle, the pipes may be less in size, than when operated at one or two pounds, pressure, but on the non-vacuum principle, and this is easily accounted for by understanding that when there is any part of a vacuum in a heating plant there can be no air-bound surface or obstructions of any kind, and with a sufficient supply of steam it must find its way to the most distant radiation from the source of supply, no matter how small the pipes may be, so that with the slightest part of a vacuum formed in a heating apparatus continually there will be a better circulation of the steam than under a pressure of five pounds per square inch.

There is no better way to familiarize one's self with the practical workings and principles of a heating system than to carefully read and study a first-class set of specifications, and for this purpose we give here the complete specifications of one of the most up-to-date exhaust steam heating systems recently constructed in the City of New York, by permission of the architects, Messrs. Kimball & Thompson, of 66 Broadway, New York City. This plant was constructed by the well known firm of heating and ventilating engineers GILLIS & GEOGHEGAN, of New York City, and to whom the writer is indebted for information on this plant.

SPECIFICATIONS

for boilers, steam heating and ventilating apparatus, power connections, pumps, heaters, tanks, etc., for the new building to be erected on West 18th, and 19th streets between Sixth and Seventh Avenues, New York City, N. Y. Messrs B. Altman & Co., owners. Kimball & Thompson, Architects, 66 Broadway, New York City.

General.

The plans accompanying this specification show generally the location of radiators, coils, pumps, electric light engines, etc., but the Architects reserve the right to change the location of radiators, piping or machinery, previous to setting or erecting of same, to accommodate the conditions of the building.

The apparatus is to be arranged to warm the building with reduced or exhaust steam, and at a pressure not exceeding five pounds to the square inch, and the entire apparatus must fill and circulate at a pressure of three pounds to the square inch.

The buildings throughout are to be heated to a temperature of seventy degrees, Fahrenheit, in coldest weather, except the stable building, which is to be heated in first story only, harness rooms to be heated to sixty-five degrees and the remainder of the first story to a temperature of sixty degrees Fahrenheit in coldest weather.

All machinery, main supply and return pipes are to be located in the basement and the vertical lines are to be placed in recesses provided in building walls for same.

All water of condensation is to be returned to the boilers automatically, by means of steam pumps, pump governors, etc., and the boilers are to be made strictly according to the detail specifications herein provided for same.

All materials of every kind are to be of the very best quality and the workmanship is to be strictly first-class, and all work and materials necessary to the complete finish of the steam plant is to be executed in the most thorough, substantial, neat and workmanlike manner and to the entire satisfaction of the Architects.

Boilers.

Furnish and locate where shown on plan, Fig. 204, under the stable building, four Babcock & Wilcox Wrought Steel Sectional Water Tubular Boilers, or equal thereto, aggregating one thousand horse-power capacity, as follows :

Heating Surface.

The heating surface of each boiler to consist of two steam and water drums 36 inches in diameter and 23 feet 3 inches long, placed above and connected to a set of fourteen sections of tubes, each section consisting of nine tubes four inches in diameter and eighteen feet long. The lower ends of the sections to be connected to a mud drum. The connections between all parts to be made by expanding wrought tubes into bored tube seats.

rought Steel.

All wrought steel for pressure parts, except tubes, to be of the best open hearth steel, having a tensile strength of from 56,000 to 62,000 pounds per square inch, to show an elongation of not less than 25 per cent., in a parallel test piece of eight inches accompanied by a reduction in area of at least fifty per cent.; to endure bending double upon itself both before and after being brought to a flanging heat and quenched.

All forgings for pressure parts to be made of the above steel by hydraulic presses and annealed after completion.

Drum Construction.

The cylindrical portion of the drum to be made of three sheets, each $\frac{7}{16}$-inch thick, the longitudinal seams butt-strapped inside and out. The seams to have two rows of rivets passing through both straps and the shell, and two rows through the shell and inner strap only, the butt straps to be bent to a proper radius in a hydraulic press. The circular seams lap-joint, single riveted. The edges of all plates to be planed.

All holes to be punched $\frac{5}{16}$-inch smaller than the diameter of rivets to be used, through steel templates, and drilled out to full size after the sheets are rolled and assembled with their butt-straps.

After drilling the straps are to be removed, all burrs cleaned off, and the plates assembled, metal to metal, with parallel turned bolts fitting the holes before riveting.

Each course to be built independently to template. The various courses and their heads to be assembled by a hydraulic forcing press, at a pressure of not less than twelve tons.

All rivets to be driven with sixty-ton pressure and held until cool.

All drum-heads to be fitted with manholes. The heads to be hydraulic-forged at a single heat, with manhole ring and stiffening plate in position, and to have flat raised seats for stand pipe and feed connections. The edges of head and armhole face to be turned off true.

The manhole plate and guards to be forged steel. The nuts case hardened. The plate 11 inches by 15 inches, to be faced and turned to a true oval to fit head.

The steam flanged 6 inches by 11 inches diameter, of forged steel, recessed to make a male and female joint, fitted with studd bolts, with taper threads and inside keeper nuts; outside nuts case hardened. Steam openings to be in boiler heads.

The drum cross boxes to be hydraulic forged from single sheets without seams or rivets.

Sections.

The sections to be built up of four-inch tubes made of the best knobbled, hammered charcoal iron blooms, of standard weight, and of such quality that a one-inch section shall, when subjected to three blows from a 1500-pound hammer dropped five feet, to be crushed into itself without showing cracks or flaws.

The tubes to be expanded into forged steel headers of serpentine form, disposing the tubes in a staggered position when assembled in the furnace.

A hand-hole of sufficient size to permit the cleaning, removal and renewal of a tube to be placed opposite each tube end, said hand-hole to have a raised seat milled off to a true surface.

The hand-hole to be closed on the outside by a forged steel cap milled to a true surface, and to be held in position by a forged steel safety clamp, closing the hand-hole opening from the inside, secured by a ball-headed bolt to insure correct alignment, and a forged cap nut. All joints to be made tight, metal to metal, without packing of any kind.

Mud Drums.

To be 12 inches in diameter and of proper width to be connected with all of the sections in the boiler by means of wrought nipples expanded into

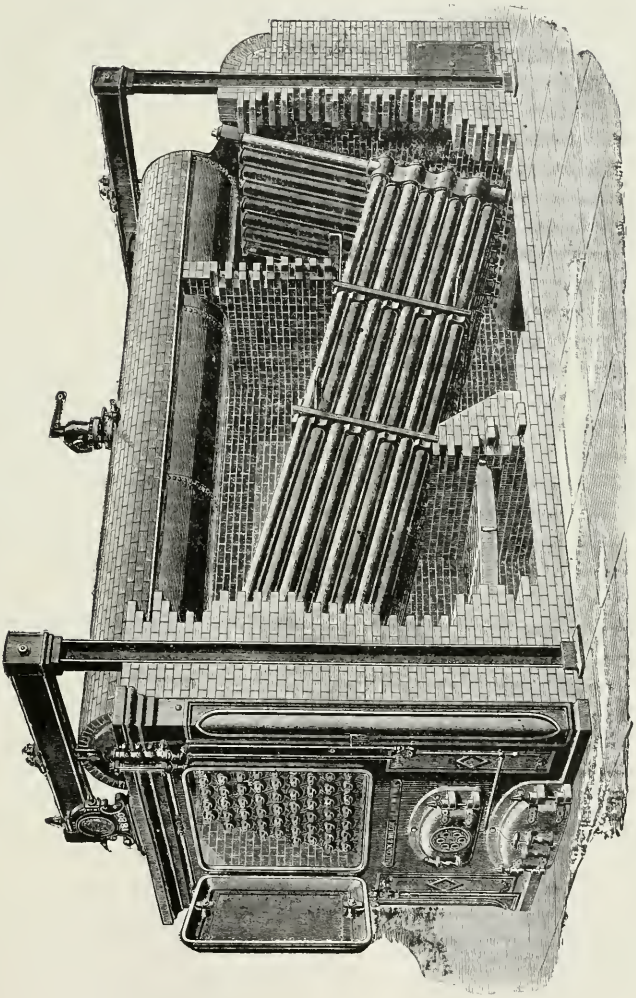


FIG. 203.

The above illustration shows the kind of boiler used.

counterbored seats. To be tapped for blow-off connections on its rear side, and furnished with hand-holes for cleaning. The hand-hole plates to be faced and cap nuts to be used for hand-hole bolts, to avoid sticking from outside corrosion.

The mud-drums to be of best car-wheel mixture charcoal cold-blast iron, tested to 400 pounds pressure.

Supports.

The boiler to be suspended at front and rear, from wrought-iron supporting frames, entirely independent of the setting, to allow for contraction and expansion without straining either the boiler or the brick-work, and to allow of repairs or renewal of the latter without disturbing the boiler or its connections.

Valves and Fittings.

Each boiler to be provided with two "Consolidated Co.'s" nickel seated safety valves, four inches diameter, set to blow at 200 pounds (unless otherwise ordered).

One Ashcroft steam gauge, with 12½-inch dial, and inside syphon, mounted in a heavy brass case.

One stand pipe fitted with extra heavy bronze mountings for glass water gauge, with special shut-off device operated from fire room floor, to allow renewal of glass when under pressure.

Three try cocks with lifting handles for operating from the fire room floor, fitted with steam metal valves arranged for re-grinding under pressure.

Independent blow-off pipes for bottom of column, and glass gauge to be carried down the front, terminating with valves at height of hand.

Feed Connections.

A combination stop and check valve of heavy bronze pattern, to be flanged directly to the drum head, operating automatically in case of rupture of feed piping.

One stop valve for feed two inches diameter, and one check valve for feed two inches diameter, to be placed hand high from boiler-room floor, connected by flanges, to allow of removal without disturbing main feed line.

Two 2½-inch blow-off valves, with loose sleeve for blow-off pipe, for building into brick-work, to allow for expansion and contraction.

Two 3¼-inch stop valves connected to steam and safety valve outlets, for cleaning hose connection.

Extra heavy brass pipe and bronze fittings, to be used for connecting all the above mountings to the boiler. All angles in feed and stand pipe connections to be made with crosses and tees for cleaning.

Cross Pipes.

The steam drums to be connected by a balance pipe upon which the safety valves are to be mounted, and a cross pipe for steam valve.

Steam delivery outlet 8 inches diameter, 14 inches flange.

Boiler Front.

The front of the battery to be of an ornamental design consisting of a heavy wrought iron I and channel beam frame fitted with large doors for access to the hand-hole plates and front headers.

The fire fronts arranged to allow for expansion and contraction. Independent frames for fire doors bolted on, and ash doors fitted with blast catches.

All joints to be fitted and faces of doors planed.

Furnace and Wall Fixtures.

Dead plates and supports, the plates to be arranged for a fire-brick lining.

Fire-brick arches and jambs for fire-door openings.

A full set of grate bars and bearers, the latter to be fitted with expansion sockets for side wall.

Two sets of flame bridge plates with bolts and backing rings, and special fire-brick for lining the same.

One bridge wall girder for hanging bridge, fitted with expansion sockets for side wall.

A full set of cleaning and ash doors for side walls giving access to all parts for exterior cleaning.

One swing damper and frame, with an auxiliary slide for closing tight when boiler is out of service.

All the necessary buckstays, tie and anchor rods, anchor plates and lintels for securing all parts in position.

Tools.

Two steel wrenches for hand-hole nuts, two tube-scrapers, with handles, two sets of fire tools, consisting of poker, slice bar and hoe. Two sets of best steam hose and cleaning pipe for blowing dust and soot from the exterior of the tubes.

Material and Workmanship.

All materials to be of the best quality, each specially adapted to the service required, and the workmanship to be first-class in every particular.

Working Pressure.

The boilers, as specified, will carry 200 pounds pressure, if desired.

Testing.

All pressure parts to be tested and made tight under hydrostatic pressure before leaving shop, as follows:

Sections, 400 pounds.

Drums, 300 pounds.

Mud-drums, 400 pounds.

When erected complete on foundations, the whole structure to be tested and made tight at 300 pounds pressure.

The boilers are to be tested by the Hartford, Fidelity, or other equally good Steam Boiler Inspection and Insurance Company, and a policy of insurance for one year is to be furnished to the owners.

This contractor is also to apply for and have the Police Department test put upon the boilers and is to supply certificate that this test has been made to the owners.

He is also to supply the necessary department boiler numbers.

Boiler Pan.

Furnish and set in boiler pit prepared for same, one Wrought Steel Pan, to be in size 54 feet long by 40 wide by 6 feet 6 inches deep, same to be built throughout of Park Bros., or equally good flange steel plates, to be not less than $\frac{5}{8}$-inch in thickness, to be riveted and put together in best manner in sections. Sheets to be flanged up and sections double riveted together, or sheets to be fastened together by means of angle iron riveted to sections of pan and then double riveted together. It is to be thoroughly calked throughout and made water-

tight, the bottom to be stiffened by means of tee irons, riveted to same, not less than five feet apart and of the full width of the pan, said tee irons to be not less than 5 inches by 2½ inches. To have band of angle iron riveted around the top of same not less than 5 inches by 3½ inches, and to have bands of angle iron riveted around the sides of same for holding down.

Pan to be painted two coats, inside and out, with best mineral paint.

In most appropriate point in pan, rivet a 12-inch flange, and continue from same to basement floor level 12 inch elbow and nipple, so that drips from engines, pumps, etc., can be continued over to and connected with lower blow-off tanks.

Masonry.

The contractor is to level up the bottom of the boiler's vault, and build proper foundation for boiler. He is also to pave in front of boiler with brick on edge, thoroughly grouted in cement, on a sand bed not less than one inch thick. He is also to furnish all masons, labor and materials and erect the boilers in substantial masonry.

All red brick to be the best quality, hard burned without cracks and with true surfaces. No bats or bulged bricks are to be used in any part of the work.

The red bricks are to be laid in mortar composed of one part cement, two parts lime and three parts sharp sand, and in laying up the walls, every third course is to be a leader course. The walls must be true to line with joints not thicker than $\frac{5}{16}$ inch.

The entire inner surface of boiler settings are to be lined with fire-bricks, furnaces to be lined with best quality fire-brick equal to Maurer's No. 1, all remaining portions of inner walls to be lined with fire-brick equal to Maurer's No. 2. The fire-bricks are under no consideration to be wet. They are to be dipped in fire clay batter and laid by rubbing down in place, in order to completely fill all joints and make them as thin as possible.

Exposed portions of the front wall of boiler settings and of the side wall towards engineer's room, to be faced with white enamel brick laid in white mortar with close joints.

The side and rear walls are to be finished with coping of fine axed blue stone four inches in thickness by twelve inches wide.

All red brick walls are to have three coats of cold water paint.

Smoke Flue Connection.

Properly connect the several boilers with the vertical smoke flue, provided by owners, by means of a No. 10 soft steel smoke pipe, to be in shape as will best suit the space provided for same. It is to be put together with angle irons, riveted and calked tight, and is to be in size 12 square feet from the easterly boiler, increased to 18 square feet at the second boiler, 22 square feet at the third boiler and from the fourth boiler to the vertical flue to be 28 square feet area. This flue is to be continued in about the direction shown, but the architects reserve the right to change the run of same.

Securely suspend this smoke pipe from the beams of heavy wrought-iron hangers, and is to have pivoted damper at each boiler and a pivoted damper in the main connection, same to be arranged so as to operate by an automatic damper regulator, as set forth below. The pivoted dampers at the boilers are each to have weighted levers and chains continued on pulleys over to front of boilers and thence down to easy operating height. The dampers at each boiler to be made as tight as possible with allowance for easy operation.

Covering Flue Connections, etc.

This smoke flue connection, for its entire length, is to be covered with 2-inch magnesia blocks, same being wired on over a galvanized mesh, leaving a space of fully 1½ inch between the pipe and the covering. This covering is then to be smoothly finished and is then to be covered with a No. 16 galvanized iron casing, fastened over the covering with lugs, so as to leave fully one inch clearance between the covering and the casing; also cover the steam drums of boilers with 2-inch magnesia blocks, smoothly finished on the outside and covered with No. 6 galvanized iron, properly fastened in place.

Damper Regulator.

Furnish and attach to the pivoted damper in the main smoke flue connection a Locke Damper Regulator, of ample capacity for controlling the draft of the several boilers, properly connected with all necessary valves on both water and steam connections.

Mains from Boilers.

Furnish all materials for and extend from 8-inch flange connecting the two drums on each of the boilers, full size pipes, and continue to and connect into a main header fourteen inches in size, placing full sized valve near where

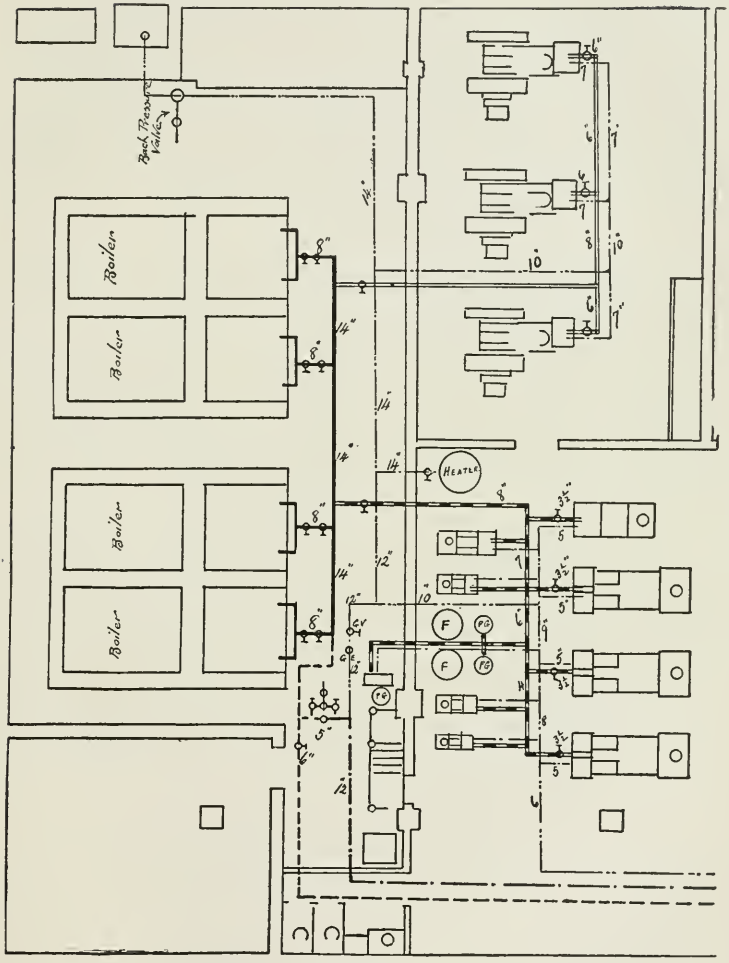


FIG. 204.

This ground plan, Fig. 204, shows the size of pipes and how they are connected to boilers and pumps.

connecting to each flange. Leave an outlet in this main trunk pipe, 7 inches in size, and from same continue a pump line in about the direction and of the sizes shown in accompanying plan, properly connecting to the elevator, fire and several small pumps, placing full size valve on this line near where connecting to main trunk pipe, so that the pumps can be in operation when the remainder of the machinery is out of commission, placing full size controlling valve on the steam connection to each of the several pumps.

Feed Water Heater.

Furnish and locate about as shown on plans, one Berryman Feed Water Heater, to be in size 51 inches by 96 inches, set on iron stands or legs, these to rest on brick foundation, capped with four-inch axed blue stone.

Furnish all pipes, valves and other fittings required, and connect main exhaust pipe to inlet on this Heater, and from outlet on heater, extend as set forth below. Also form pass-by around heater, full size, so that exhaust may be discharged into the heater, using three gate valves in this connection, or direct to above roof of building. Heater to be 600 H. P.

Boiler Feed Connections.

Furnish all necessary pipe, valves and fittings, and make all feed connections from pumps to the feed water heater, and from thence to the boiler, with all valves and pass-bys complete, so that water can be warmed by passing through the heater and thence to boilers, or so that in case of repairs to the heater, the water can be pumped direct to the boilers without interfering with the running of the plant. This feed pipe throughout is to be made of heavy brass tubing, with heavy cast brass fittings, and where same is exposed and uncovered around boilers, both pipe and fittings are to be highly polished.

Steam Pumps.

Furnish, set and connect complete, where shown, or where directed, six (6) Worthington, Deane or other selected duplex steam pumps with brass lined cylinders.

One of these to be in size 18 x 10 x 12, and to be of the underwriters' pattern and to be used as a fire pump only; one to be in size 10 x 6 x 10, to be used solely as a house pump; two to be in size $7\frac{1}{2}$ x $4\frac{1}{2}$ x 10, to be used for returning the water of condensation to the boilers in connection with pump

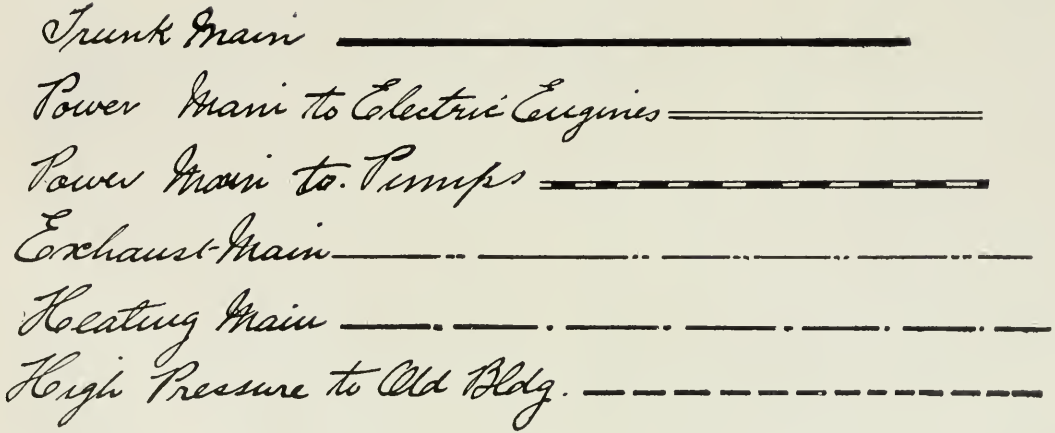

Trunk Main
Power Main to Electric Engines
Power Main to Pumps
Exhaust Main
Heating Main
High Pressure to Old Bldg.

FIG. 202.

governor, feeding the boilers, and to be cross-connected with the house pump to act as auxiliary house pumps; one to be in size 6 x 4 x 6, to be used in connection with high pressure pump governor and to be cross-connected with the two 7½ x 4½ x 10 pumps, so that any of these three pumps can act with the low pressure or high pressure governors; and one pump to be in size 5½ x 3¼ x 5, to be used in connection with the pump governor, for automatically discharging contents of the lower blow-off tank to the upper blow-off or cooling tank.

Fig. 205 shows what the various pipes in plan 204 are.

These pumps are to be set on proper foundations, faced with enamel brick and capped with four-inch, machine-dressed coping, which is to overlap the piers one inch all around.

Furnish all valves, pipes and fittings and make all steam, drip and exhaust connections to these pumps, also all connections for feeding the boilers, returning the waters of condensation back to the boilers and leaving the house pumps ready for plumber's suction and discharge connections, making all connections for filters, with pass-by valves, etc., complete.

Feed Water Filters.

Furnish and connect between the pumps, boilers and feed water heater two Ward patent feed water filters, each to be of 400-horse power capacity, with zinc box and filling of animal charcoal, for removing grease, etc., from the feed water before same passes to the boilers. These filters to be so connected as to allow of their being cleaned or repaired without interfering with the operation of the plant. They are to be connected with all necessary valves and cocks complete for the proper blowing out of same, so that boilers can be fed either through or round same. They are to have covers with rings in the top and chain and block for the easy removal of said covers, so that the filters can be readily cleaned.

Injectors.

Furnish and connect complete to boilers with all necessary steam and water connections, two No. 7 Nathan double tube injectors, with valves and strainers and to be so arranged that either injector can be operated on any of the four boilers.

Blow-off and Cooling Tanks.

Furnish and set in the boiler pan, in about the location shown, two tanks, one to be suspended from the ceiling beams and the other to rest on cast iron saddles on the floor of boiler pan.

The lower tank to be in size 3½ feet diameter by 8 feet long, and the upper tank to be in size 3½ feet diameter by 9 feet long. They are to be made throughout in the best manner of Park Bros. or equally good flange steel, shells to be ⅜-inch thick and the heads to be ½-inch thick. These tanks to be riveted, calked, braced, and tested to withstand a hydrostatic test pressure of 150 pounds per square inch, and to have manhole in one end fitted with plate, bolt, guard and gaskets complete.

Drip Tank Pump and Governor.

Furnish, set and connect complete along side of this lower tank, one duplex steam pump, size 5½ x 3¼ x 5. Also furnish and set one Kieley Automatic Pump Governor and connect same to tank and pump, so that drips from engine, pumps, etc., discharging into lower tank will be automatically pumped to the upper drip or cooling tank, carrying from the upper tank a 2½-inch discharge pipe to the sewer.

The lower tank is to be arranged so as to be automatic in its discharge upper tank and the drips, etc., are to be held sufficiently long in the upper tank to allow of their flowing to the sewer at such temperature as will not interfere with the Health Department.

The drips, reliefs, etc., from the piping, engines and pumps are to be continued through 12-inch opening left in pan down into pan and thence along back to lower tank, so that in all cases, drips from engines, etc., will pass to the tank by gravity.

Condensing Coil.

In the upper drip tank, place a condensing coil, containing about (150) one hundred and fifty lineal feet of 1½-inch heavy brass steam pipe, same to have extra heavy 2½-inch cast brass headers, and to this coil connect the Croton suction for boiler feed pump with pass-bys, so that the water can pass through said coil or direct to pump, the object of this coil being to cool the water in the upper tank to below 100 degrees temperature, as required by the Board of Health.

Plumber will leave outlet in his Surge Tank for this special connection.

Vapor Pipes.

Continue from each of the blow-off and cooling tanks, a vapor pipe three inches in size, and connect same into a main vapor pipe four inches in size, and continue this main vapor pipe to the above roof of building, placing a gate valve on the vapor connection near each tank and capping this vapor pipe at roof with an approved condenser with drip carried down to and connected to upper cooling tank.

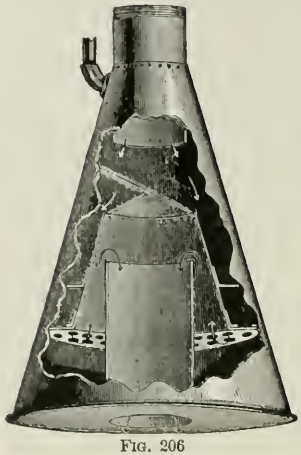


Fig. 206

Fig. 206 shows a roof condenser or exhaust head. The blow-off connections from each of the several boilers is also to be connected to this lower drip tank and a direct connection is to be made from the boilers to the sewer, with all necessary valves. Plumber will leave in his sewer pipe necessary outlets for this contractor.

Hot Water Tank.

Furnish and erect, where directed, one hot water tank for the supply of hot water for house purposes, same to be in size 3½ feet diameter by 8 feet long, and to be neatly suspended from iron beams at such places in the building as may be directed. This tank to be built throughout in best manner of Park Bros. or equally good flange steel, shell to be ⅜-inch thick, heads ½-inch thick. It is to be properly riveted, braced, calked, and tested to withstand a hydrostatic test pressure of one hundred and fifty pounds per square inch; to have manhole in one end, fitted with plate, bolt, guard and gaskets complete; to have all necessary flanged outlets ready for Plumber's connection.

In this tank place a coil of two-inch heavy brass steam pipe, containing a total of about 50 lineal feet; to have extra heavy three-inch brass headers, and to this tank make an exhaust connection with pass-by valves, so that the exhaust can pass through the coil or pass by at the will of the engineer. Also make one-inch live steam connection to this coil and ¾-inch return connection, carried back to high pressure pump governor. These connections to be made with all necessary valves, so that either live or exhaust steam can be used at the will of the engineer.

Power and Exhaust Piping.

From the main fourteen (14") inch trunk pipe hereinbefore mentioned, continue a main power pipe ten inches, and continue of the sizes and in about the direction shown on plan, and make connection to three electric light engines, the connection to each engine to be the full size of the inlet on same. Place a full size controlling valve before dropping down to engine and a full size controlling valve near where branch connects to main trunk pipe, and from each engine continue an exhaust pipe one size larger than the outlet on engine and connect same into the main 14-inch exhaust pipe, which is to be carried of the sizes and in about the direction shown, over to and outside of the buildings alongside of the vent flue, and thence to and above roof of building, and there capped with an approved exhaust head with drip carried down to blow-off tank in cellar.

Place full size gate valve on the exhaust connection to each engine, and connect the exhaust to the feed water heaters and hot water tank, as hereinbefore specified, with all necessary pass-by valves.

The drips from the engines to be properly connected to the blow-off tank, with all necessary Kieley Standard Traps.

Continue from 14-inch header a 7" special pump trunk line over to and connect to the several pumps hereinbefore mentioned and to three elevator pumps, placing full size controlling valve near the header and on the connection to each separate pump, and from each of said pumps carry an exhaust pipe one size larger than the outlet and connect into the main exhaust trunk pipe hereinbefore mentioned with full size gate valve on exhaust connection to each pump, also all drip connections to pumps with all necessary Kieley Standard Traps.

High Pressure Steam and Return Mains.

From 14-inch header main, start out out with a 5-inch main for supply to hot water tank, cooking apparatus, etc., and continue this main through vault and connect with main in present building, 18th Street side, also leave outlet for connection to new addition with valve, running all necessary mains in this building.

Separators.

Furnish and place in each high pressure main near where first engine or pump is taken off, Stratton Separators, full size of pipe, with large relief pipe

carried from same and discharged separately through Kieley Standard Traps to high pressure pump governor, with pass-by to drip tank, with all necessary valves.

Exhaust Receivers.

Furnish and place on the exhaust pipe from each engine an exhaust receiver, same to each be of an area equal to four times the area of the cylinders, to be not less than six feet long and to have special caps at each end, the exhaust to enter 18 inches into each end of receiver and to be slotted 12 inches long, all as per special design furnished by the architects, with a one-inch relief pipe carried to drip tank and discharged through appropriate Kieley Traps into tank, with pass-by to sewer.

Carry high pressure return back and connect to high pressure pump governor hereinafter mentioned.

Heating Main.

All fittings used on the heating mains to be reducing fittings and are not to be bushed.

From an 8-inch outlet left in the trunk main near boilers, start out with a heating main eight inches in size and connect into a 14-inch heating trunk main, and continue same through vaults and connect to heating main in the present building, and there connect to the several rising lines and basement radiators in new addition and Stable Building, as hereinafter mentioned. This main is to be gradually reduced in size as the several rising lines, etc., are taken off, but is to be not less than the sizes shown on plan. Said mains are to be securely suspended from beams with neat and strong expansion hangers, and are to be put up with all due allowance for expansion and contraction.

Connections to rising lines, etc., are to be taken as far as possible from the top of the heating main.

Return Main.

Furnish and run a return main under the basement floor and vault in about the same general direction as the steam main to be reduced in size about as follows: All piping corresponding to 7-inch and larger in the heating main to be made three sizes less for the return main. That corresponding to 6-inch steam main to be two sizes less and the remainder of the return piping to be one size less than the steam main.

This return main is to be carried under the floor in trenches provided for same and is to rest on expansion chairs.

Owners will build and cover the trenches, but this contractor is to furnish the necessary cast-iron chairs with expansion rollers.

Properly connect the return rising lines to this return main and make due allowance for expansion and contraction.

Rising Lines.

Furnish and run about 12 sets of vertical steam and return rising lines, to be generally 2½-inch in size to the 5th story and 2-inch in size to the top story. Return rising lines are to be generally one size less than the steam rising lines and both lines to be plugged at top, full size, ready for continuing to two additional stories, if required. Also increase the size of and continue the rising lines in the present old building for connection to radiators, etc., in new 5th story and pent houses.

Air rising lines to be ½-inch in size for their entire length.

These vertical rising lines are to be properly connected to the horizontal steam and return mains in the basement, and are to have full size controlling valves on both steam and return connection, and they are to be so looped in the basement as to make all due allowance for expansion and contraction.

Relief Pipes.

From the bottom of each steam rising line, carry separate relief pipe with full size valve on each separate connection to each separate riser, also from the ends of the steam main and such other points as may be necessary, carry relief pipe with full size valve and connect into a main relief pipe, which is to be gradually increased in size, same to be carried back to and connected to the receiver of the automatic pump governor. Relief pipes from any one rising line or from end of main to be not less than one inch in size.

The above refers to both the present and the new buildings.

Reduction Pressure Valve.

The Kieley high pressure reducing valve.

Furnish and place in the heating main about where shown, a full size Kieley Patent Reducing Pressure Valve, same to be put up in the form of a pass-by, with three controlling valves, so that the reducing pressure valve

can be removed for repairs without interfering with the running of the apparatus.

Back Pressure Valve.

Furnish and place in the main 14-inch exhaust pipe a Kieley Patent Back Pressure Valve, full size, and from full size outlet carry a full sized pipe over to and connect with the main heating trunk pipe outside of reducing pressure valve, and on this connection near the main exhaust place a full sized gate valve.

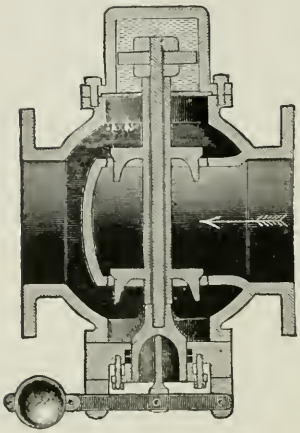


Fig. 207.

Grease Extractor.

In the said exhaust connection to the heating main, place a full size De Ryeke patent grease extractor, properly connected, with necessary drip valves, gauge glass, etc., complete.

Lubricators.

Furnish and attach to each engine and pump one Nathan sight feed lubricator of one pint capacity, and to electric light engines one quart capacity, same to be properly connected with all necessary valves complete.

Special Gauges and Connections.

Furnish and place where directed, one approved polished marble gauge board, two inches thick, designed and lettered as directed, and on this board, place one ten-inch high dial pressure steam gauge for each boiler, properly connected, one ten-inch dial low pressure gauge connected to the heating main for direct radiation outside of the reducing pressure valve, and one ten-inch dial gauge connected outside of back pressure valve, so that the engineer in charge can readily see in the engine room the pressure carried on the machinery connection to be made on each gauge with ¾-inch brass nickel-plated pipe and fittings and shut-off valves. These gauges to have nickel rims. Also furnish and place one Howard nickel rim eight-day marine clock, pipe and fittings for connection of all the above to be polished brass nickeled.

Pump Governors.

Furnish and set up complete in connection with the pumps for purposes hereinbefore described, three large size Kieley Patent Automatic Pump Governors, one to be for returning the water of condensation back to the boilers from the heating system, one to be for returning the water of condensation from the high pressure system, etc., and one to be for the automatic control of the water in the drip or blow-off tank.

These pump governors are to be properly set on brick foundations capped with blue stone, and are to be properly connected to the several pumps for the purposes described, with all necessary pass-by valves, so that in case of repairs to the governor, pumps can act direct on the returns, or so that the returns can pass direct to the blow-off tank, in case of repair to pumps.

Radiators.

The heating of the new building, and new fifth story, and pent-houses on present building, and sleeping room in the 6th story of Stable Building, is to be

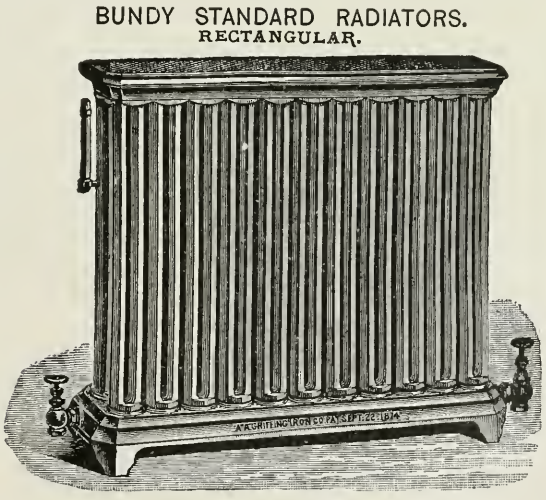


Fig. 208.

accomplished by means of Vertical Radiators, of the Bundy Standard Pattern, with perforated iron tops and molded bases, flat coils for tops of shelves,

counter coils or foot warmers, and Indirect heating stacks, operated on the re-heated air principle, all similar to those used in the present building, located where shown on plans or as may be directed.

The shelf coils are all to have galvanized iron pans placed under same, riveted and soldered water tight. The foot warmers are to be similar to those in the present building, and the covers are to be cast to suit the curves of counters. The Stacks to be hung on heavy wrought iron hangers. Floor registers to be extra heavy.

Heating Surface.

There is to be in all not less than 19,000 square feet of heating surface, divided approximately as follows:

Bundy Surface	9500	square feet,
Shelf Coils	5300	" "
Foot Warmers	2000	" "
Indirect Stacks	1500	" "
Coils in Stable Building	700	" "

All of the above to be proportioned to give the temperatures hereinbefore mentioned.

Radiator Connections.

Properly connect these radiators, etc., to the horizontal and vertical systems of steam and return pipes, placing full-size controlling valves on each steam and return connection. No steam connection to be less than one inch and no return connection to be less than $\frac{3}{4}$ inch. Radiators, etc., containing more than fifty square feet of radiators are to have $1\frac{1}{4}$ inch steam connections and one inch return connection.

Air Valves.

Furnish and attach to each radiator throughout the building approved selected automatic air valves, same to be properly connected to air rising lines, the vertical air-rising lines being connected in cellar to a system of horizontal air lines, which is to terminate in a sink with open end.

Ventilation of Boiler, Engine, and Pump Rooms.

Owners will provide on the roof of the Stable building a fire-proof housing, which will connect with the vertical vent flue, this contractor to place in the openings left in his housing two 72-inch Direct-Connected Seymour Steam

Pressure Exhaust Fans, fans to have conical casing and solid ring frame, Siemens-Martin steel disks and steel shaft running in self-oiling bearings, each fan to have twelve blades, with forks of gun metal. Each fan is to be driven by a six-horse power vertical two cylinder shaft engine, the extended shaft of engines forming the shaft of the fans; each fan to be capable of discharging under the flue conditions 40,000 cubic feet of air per minute when only one fan is running. Engines to have self-oiling sight feed lubricators throughout, and the crank pins to run in oil and water. Each fan and engine to be self-contained, and the engines are to be supported entirely from solid ring which forms the frame of the fans.

This contractor will continue from the main trunk main in front of boilers a 2-inch steam pipe, carry same up through shaft and connect to these engines, full size of the inlet on engines, and from the outlets of engine he is to continue to and above the roof of the building a 2-inch exhaust pipe, with gate valve at exhaust connection to each engine, capping this exhaust pipe on the roof with an approved galvanized iron condenser with drip continued over to and connected to the drip from large condenser.

He is to carry down a drip pipe from housing and connect with the lower blow-off tank in cellar, placing full size controlling valves on steam, exhaust and drip connections to this engine, also supplying with each engine a Kieley Standard Trap No. 1.

The vertical steam pipe for the engines is to be relieved at the bottom with Kieley Traps, with discharge of said trap continued similar to other discharges.

Steam pipe to be covered for its entire length with 2 inches of magnesia covering, canvassed and banded similar to other covering.

Ducts.

From opening left in vent shaft on east side of the Stable building, continue galvanized iron ducts on the ceiling of basement and connect separately to the boiler room; said ducts to be of the same area as the area of the shaft, not to be over 12 inches deep.

The main duct is to be divided into three equal parts, one-third of its area discharging into the boiler room, one-third to the engine room and one third to the pump room. Each of said discharges to have a tight fitting pivoted damper with approved handle. The outlets into engine and pump

rooms are to be covered with approved mesh or screen. These ducts to be painted three coats of color selected.

From the engine room carry a separate duct. over to and connect with vertical vent shaft, continuing this duct on engine room ceiling of such a shape as will be directed, with outlets looking down over each engine with pivoted dampers. A similar duct is to be carried on the pump room ceiling with outlets looking down over pumps, etc.

The area of each of these ducts to be one-third the area of the vertical vent flue.

All ducts throughout to be made of heavy iron properly riveted and soldered air tight and ducts to be put together with angle iron frames, properly bolted. Particular care is to be used in the running of these ducts and a drawing of same is to be submitted to the architects, previous to the making of same.

Non-Conducting Covering.

All steam, power, exhaust, heating, return, relief and drip pipes throughout the basement and trenches and all rising steam and return lines, exhaust and vapor pipes throughout the building are to be covered with Keasby's magnesia sectional covering or H. W. Johns' fire felt covering, as selected, with molded fittings, all properly canvassed and banded on, the canvas to be painted three coats of paint of an approved color.

The blow-off tanks, feed water heater, pump governors and grease extractor are to be covered with magnesia or asbestos blocks one inch thick, properly wired on and smoothly finished on the outside, same to be painted three coats of paint.

Lagging of Pumps.

All elevator pumps and all pumps supplied under this contract to be covered with magnesia blocks 2 inches thick, specially made for easy removal without damage to same, and over this covering place a Russia iron lagging with polished brass band all put up with bolts and in sections for easy removal without damage to same. Heads to be polished spun brass.

Valves.

All valves throughout are to be of Jenkins or Fairbanks pattern, and those on high pressure piping are to be specially made for high pressure duty.

Valves on radiators are to have nickel plated trimmings with hard-wood wheels.

All gate valves throughout are to be Chapman, or equal thereto.

Fig. 209.

Protection.

Wherever pipes pass through floors and ceilings, and wherever necessary, they are to be encased in heavy galvanized iron tubes having flanges at both ends.

Wherever branches to radiators pass through floors they are to have heavy cast brass polished floor plates neatly and securely screwed to the floors.

All piping is to be placed at least one inch from woodwork, and the work throughout is to be done in accordance with the rules and regulations of the N. Y. Board of Fire Underwriters.

Painting and Bronzing.

All piping in cellar and exposed ironwork in connection with this apparatus is to be cleaned and painted one coat of Japan varnish.

All pumps and engines supplied under this contract are to be painted of a color as may be directed and striped with gold leaf on completion.

All radiators and exposed piping throughout the building and above the basement is to be thoroughly cleaned and painted one good coat of yellow ochre smoothly applied and finished with bright gold bronze, said bronze to be rubbed on dry and finished with a coat of white varnish.

Sewer Outlets and Water Connections.

The Plumber will have all necessary outlets in the sewer pipe and make all suction and discharge connections to the pumps not included in this specification.

General.

All materials throughout are to be the best of their several kinds and the workmanship is to be strictly first-class and the whole plant is to be erected complete and satisfactory in every respect.

Note.

Where columns are located in boiler pan, they are to be encircled with wrought iron pipes 7 feet high, screwed into flanges riveted to the bottom of pan.

All pipes and fittings on high pressure work to be designed to carry one hundred and fifty pounds working pressure, put together with flanges, if necessary, same to be recessed at back and calked with copper, if in the opinion of the contractor this is necessary, or if directed so to do by the architects.

This contractor is to furnish temporary heating coils for new buildings for drying out purposes and keep the buildings to a temperature of fifty degrees Fahrenheit when door openings are closed with temporary doors and windows with muslin screens.

General Conditions.

The manner of making the connections between the new steam plant and the piping and fixtures of present building, shall be done instrict accordance with the instructions of the architects acting for the owner and at such time or times as the owners shall direct. So that no injury or damage or annoyance will be caused to the business conducted on the premises, the owner must be consulted at least four or five days in advance of beginning the work of making said connections, and the manner of doing such work must be satisfactory to the owner.

The owner will, on sufficient notice being given him by the contractor for steam heating, in writing, not less, however, than six days previous to the time wanted, give possession of such part or portion of the present building as it may be possible to relinquish, but in no event shall the making of such connections between old and new work be done in the daytime during business hours, but shall be done entirely at night, beginning work not earlier than 6:30 P. M. and ceasing work at 4:00 A. M., leaving the premises clear of material and tools, and all rubbish shall be swept up and removed from the building.

No inflammable material used in any part of this work shall be stored on any of the floors. All such material shall be stored in vaults under the sidewalks on either side of the streets, the place to be designated by the owner and architects.

The work in connection with the erection of the fifth story and Pent Houses over present building on 18th and 19th Streets and Sixth Ave., will not be commenced until after the completion of the new extension.

In the carrying out of the work undertaken under this specification, no extra allowance will be made contractor for any interference from other

trades, it being understood that the several trades employed in the erection of this building shall be permitted to work at the same time. No contractor will be allowed to remove or deface work of other contractors in the performance of his work, and should the same occur through carelessness on the part of the workmen in his employ, then the same to be made good at his expense.

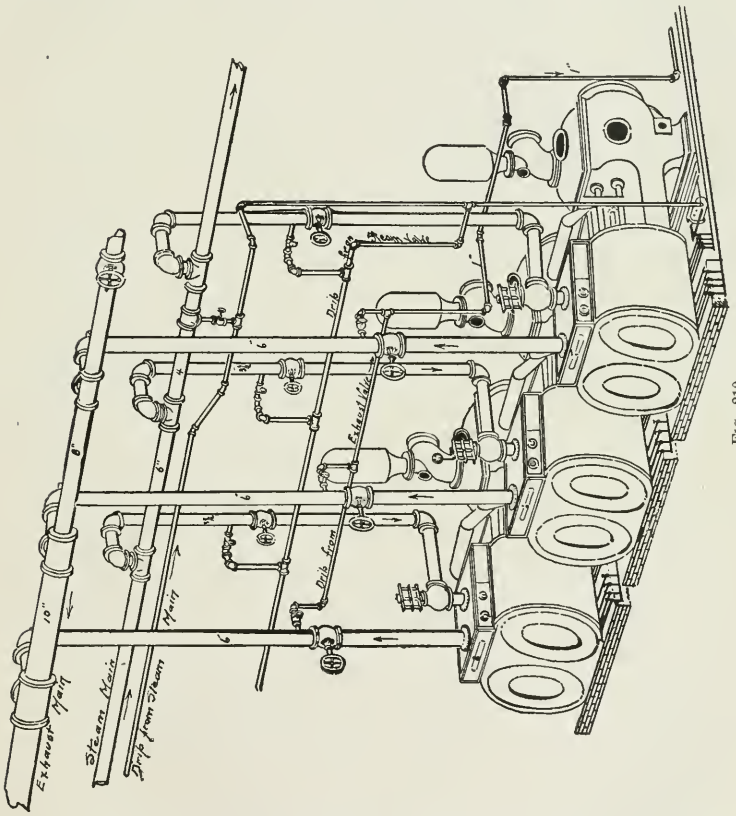


FIG. 210.

No extension of time will be granted, beyond the time set for the entire completion of the work undertaken under this specification, for changes in plans not involving any material increase of the character or cost of the

work, unless such changes are additions to the work undertaken herein, in which case the architects shall be the judges as to the extent of time to be granted.

All the foregoing conditions are to be strictly followed and lived up to by the contractor, and he must hold himself responsible for any damages to the owner for any negligence on his part, or that of his workmen, in carrying out said conditions and requirements. The owner will do all that is possible to facilitate the contractor.

In the carrying out of the work of adding the fifth and sixth stories over present building, or any of the matters and things described in the within specification as applying to alterations and improvements in present building, the same conditions as stipulated for the general contract shall prevail.

The illustration, Fig. 210, shows the system of connecting the various pipes to pumps in the heating plant just described, and in which there are some nice points that are of importance and should be interesting to the heating engineer.

In the first place it is important to notice the proportioning of the size of pipes, both to and from the pumps on engines; and as the pipes are of large size and intended to carry high pressure of steam, there will be a considerable amount of expansion to take care of in the pipes, and as the ordinary slip expansion joint is not reliable for high pressure work, the expansion and contraction of the pipes will have to be provided for in the manner the connections are made with fixed joints throughout. So it will be seen that this important feature is very carefully carried out in the connections as shown in Fig. 210 by taking the lateral branches from the mains at right angles to same, then carrying them down to pumps having a sufficient length to allow for movement in expansion not only of the main lines, but the branches themselves without producing any dangerous strain in any part of the system. The supplies to the pumps, as will be noticed, are taken from top of main steam supply so that the steam delivered to the cylinders will be as dry and free from condensation as possible. Another important point worthy of special notice in the system of pipe connections shown in Fig. 8, is the provision made for draining the supply pipes to pumps from a point above the controlling valves, so that in starting up any pump after being out of service for any length of time, dry steam only will pass to the cylinder, while if connected without these special drips a body of water would lodge in the vertical

connections above the controlling valves, which could only escape through the steam cylinders of the pumps.

Setting Horizontal Tubular Boilers.

We show in illustration, Fig. 211, the general method of setting horizontal tubular steam boilers, which will prove valuable to fitters in laying out such work, and the following table will save time in figuring on the number of bricks required for the average size boiler.

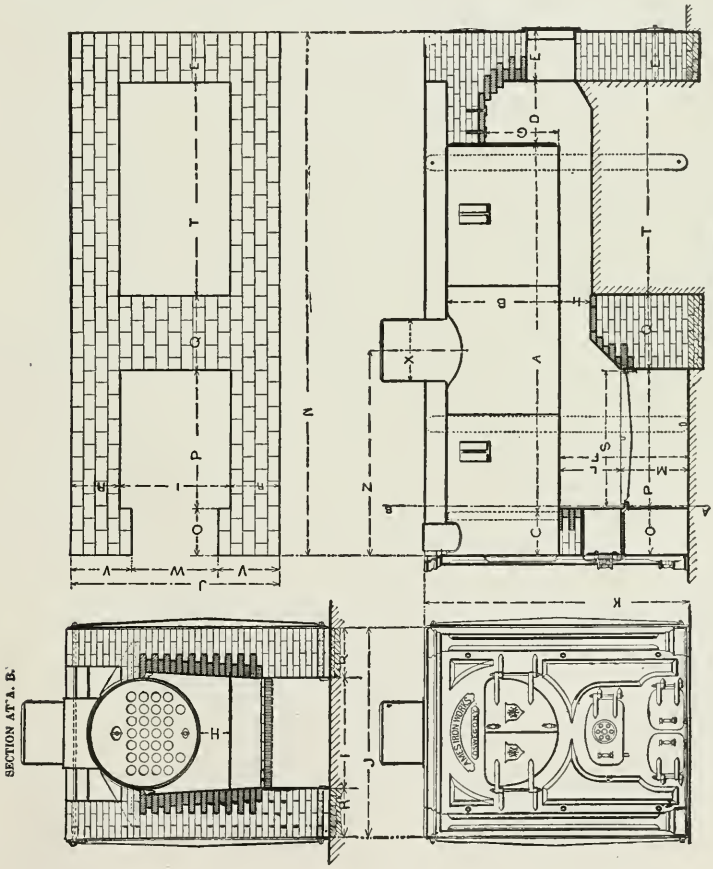


Fig. 211.

SETTING FOR HORIZONTAL TUBULAR BOILERS, FLUSH FRONT.

REFERENCE LETTERS ON FIG. 211.

No.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Z	No. of Fire Brick.	No. of Com'n Brick.
	Ft.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	Above Floor Level.	
1	8	30	12	20	16	42	19	8	30	62	79	20	22	144	13	29	12	16	28	74	2	20	22	18	65	650	7500
2	9½	30	14	20	16	42	19	8	30	62	79	20	22	164	15	35	12	16	34	86	2	20	22	18	63	700	8000
3	8	36	14	20	16	42	24	10	36	68	85	20	22	146	15	35	12	16	34	68	2	20	28	20	68½	750	8500
4	10	36	14	20	16	42	24	10	36	68	85	20	22	170	15	45	12	16	44	82	2	20	28	20	66	770	8700
5	10	42	16	20	16	42	28	10	42	76	91½	20	22	172	17	45	16	17	44	78	2	20	36	22	67	790	9000
6	10	44	16	20	16	42	30	10	44	76	91½	20	22	172	17	55	16	16	54	68	2	20	36	22	67	800	9100
7	12	44	16	24	16	42	30	10	44	76	91½	20	22	200	17	55	16	16	54	96	2	20	36	22	79	830	10000
8	14	44	16	24	16	42	30	10	44	76	91½	20	22	224	17	67	16	16	66	108	2	20	36	22	89	920	10500
9	14	48	16	24	16	42	32	12	48	88	97	20	22	224	17	67	16	20	66	108	2	24	40	26	89	1000	11000
10	12	54	16	24	20	42	36	12	54	94	103	20	22	204	17	67	16	20	66	84	2	24	46	30	79	1100	12000
11	12	60	17	24	20	42	42	12	60	108	110	20	22	205	18	73	16	24	72	78	2	27	54	32	79	1200	13200
12	14	60	17	24	20	42	42	12	60	108	110	20	22	229	18	73	16	24	72	102	2	27	54	32	69	1300	14000
13	14	62	17	24	20	42	44	12	62	110	110	20	22	229	18	73	16	24	72	102	2	28	54	32	69	1340	14200
14	14	64	17	24	20	42	46	12	64	114	117	20	22	229	18	73	16	25	72	102	2	28	58	36	69	1380	14400
15	14	66	17	24	20	42	47	12	66	114	117	20	22	229	18	73	16	24	72	102	2	28	58	36	69	1380	14600

Webster System of Steam Heating.

This system which is becoming popular in many places, is the circulating of steam for heating purposes at or below the pressure of the atmosphere. The arrangement consists primarily of a thermostatic valve, which is shown in Fig. 212.

This valve containing a stem of hard rubber compound which expands under increasing temperatures. The seat, which is the outlet, is at the top, and is arranged for ready adjustment by a screwdriver. It is capable of being set so that it will open at any degree of temperature less than that of steam at atmospheric pressure. In operation it then stands closed while steam is in the coil and in contact with the stem, but as soon as condensation collects around it, it shortens and opens the aperture to the return pipes, in which a suction or partial vacuum exists. One of the standard sizes adopted is capable of drawing 200 square feet of surface in active condensation.

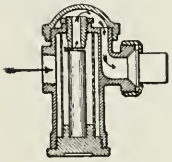


Fig. 212.

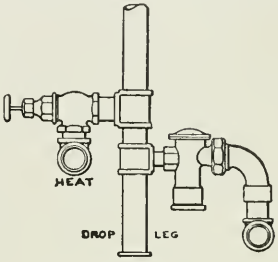


Fig. 213.

It will be evident that this little temperature trap, for such it is in effect, can be equally well applied to the foot of riser pipes, as shown in Fig. 213 to the ends of horizontal lines, to changes of size of pipes, and in fact to any desired dripping point.

Heavy condensation of any part can be cared for by multiplying the number of thermostatic valves at that point.

Care should be exercised that the valve is so placed that dirt and scale in the pipes do not fall into it direct and choke its inlet. This may be provided for by the drop-leg shown in Fig. 213. Its form is, however, such as will allow for a certain amount of sediment to deposit around the stem, which is covered by a perforated screen of simple character.

In the basement, engine-room, or boiler-room, is placed the return pump, as shown in Fig. 214, which may be a direct acting "wet-vacuum" pump, and is regulated to maintain a constant amount of suction.

The return pipes being united and brought to this pump, it is set to receive the condensation and to exert an extra suction of from one to 15 inches

of mercury, according to requirements. A pump for a radiating surface of 20,000 square feet has a steam end six inches in diameter, and will make about 100 feet piston speed per minute. Its exhaust is taken into the heating main and it is thus operated nearly as a reducing valve, or it may be taken direct to the feed water heater and there condensed. The delivery of the hot returns can be effected in more than one manner.

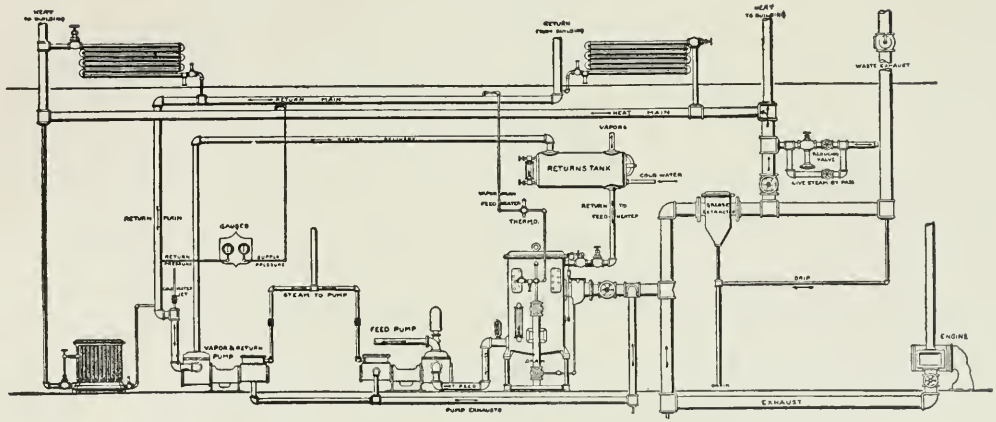
The best system has been found to be to deliver the whole into a separate "hot well" or returns receiver, from which free egress for the air and vapors can be afforded to the atmosphere and time allowed for the operation to effect itself thoroughly. Such a receiver is shown in Fig. 214, and it may advantageously be provided with a ball-cock and float, whereby any necessary auxiliary cold water supply may be automatically introduced into the returns. From this receiver the returns gravitate to the feed water heater as desired, centraled by the automatic valve upon the heater. The returns may, however, be delivered direct to the feed water heater. From the feed water heater the feed pump draws its supply under a slight head automatically, its operation being controlled by an automatic valve which is connected to its steam supply.

Description of the Webster Feed-water Heater.

It is a closed or sealed chamber, rectangular in form, provided with an upper inlet for the feed supply, which may be hot returns or cold water, or both, and an inlet for steam provided with an independent oil separator or grease extractor, operating upon the steam previous to its entry to the interior. Upon entering the steam encounters a set of oppositely inclined and perforated traps of copper sheet, over which the feed water from above is spread and percolates in a very finely divided condition, inviting most effectively the absorption of heat from the ascending steam particles. Any vapor or gases that escape the condensation of this process encounter above the upper tray a coil of parallel brass pipes through which the entering feed-water passes on its way to the trays. The effect is thoroughly to condense such gases or vapors and leave them in a condition ready for removal by the air pipe provided, which may be treated, as shown by connection through a thermostatic valve into the vacuum return system, or may vent to the atmosphere. The body of heated water, accumulating in the lower portion of the heater, affords

WEBSTER SYSTEM OF STEAM HEATING.

PATENTED.



WEBSTER HEATER AND PURIFIER COMBINATION.

FIG. 214.

a desirable opportunity for the settlement of solids, to be drawn off by the inclined bottom and drain pipe below, which is also provided with an extension to the water surface to draw off floating scum or impurities of light specific gravity. The outlet to the feed-water heater is provided under a plate hood extending down into the body of water and excluding the surface impurities. Upon the normal water surface is arranged a copper float box, operating, through the only exterior gland, a lever, which may be arranged as shown to control the water supply, or if desired to control the steam supply to the feed pump.

The feed water-heater having thus raised the temperature of returns and cold feed, the released air can be very completely removed, as described, previous to its transference to the boiler, by the connection of the top of the feed water heater into the return system.

One further and very remarkable feature of this system must be noted. It is quite practicable to operate the returns from radiators situated below the floor of the engine room, or below the level of the return pump, or to lift the drainage of any given portion to quite a considerable extent. The partial vacuum maintained and which extends from the return system will handle a much greater height of return than its theoretical value in inches of water.

Experiment has shown that a thermostatic valve, having connections of an area of .1 of a square inch or equivalent to a standard pipe of ¼ inch diameter, will convey the condensation and vapor from 160 square feet of radiating surface, which may be safely put in practise at 100 square feet. So small a pipe is, it is true, inadvisable in steam practise merely on account of its liability to damage, and it has therefore been usual to connect the thermostatic valve by ½-inch pipe. This size may, in exposed or long horizontal lines, be still further increased to ¾-inch diameter, but additions thereto as other return connections are brought into it, need only be made in the original proportion of .1 of a square inch to 100 square feet of surface. The accompanying comparative diagram of returns on both systems will show that quite a considerable economy is to be effected in this way over a two-pipe gravity system, and of course no air pipe lines are needed at all.

In a large building such as a modern office building, in which the riser lines are very extensive, the economy is quite considerable.

COMPARATIVE PROPORTIONS OF RETURN PIPES IN VACUUM AND GRAVITY SYSTEMS.

Vacuum Return.	Heat.	Gravity Return.
100 sq. ft.	100 sq. ft.	
$\frac{1}{2}$″	1″-$\frac{1}{4}$	1″
100	100	
$\frac{1}{2}$″	1″-$\frac{1}{2}$	1″-$\frac{1}{4}$
100	100	
$\frac{1}{2}$″	2″	1″-$\frac{1}{2}$
100	100	
$\frac{3}{4}$″	2″	1″-$\frac{1}{2}$
100	100	
$\frac{3}{4}$″	2″-$\frac{1}{2}$	2″
100	100	
1″	2″-$\frac{1}{2}$	2″
100	100	
1″	3″	2″-$\frac{1}{2}$
100	100	
1″	3″	2″-$\frac{1}{2}$
100	100	
1″-$\frac{1}{4}$	3″-$\frac{1}{2}$	3″
100	100	
1″-$\frac{1}{4}$	3″-$\frac{1}{2}$	3″

Hot Blast Fan System of Heating and Ventilating Buildings.

Where thorough and complete ventilation is required, there is perhaps no system in use equal to that where mechanical means are used such as the fan, or forced blast systems.

And the large number of prominent buildings of every kind recently equipped with such heating and ventilating systems, with the results obtained, give sufficient proof of their superiority over all other methods of warming and ventilating large buildings. It is entirely possible to completely heat any building by other methods to the desired temperature at all times, and under every condition of the weather, but it is not possible to change the air of large buildings in a uniform manner by natural draft or by heated flues. Therefore to produce a complete and reliable heating and ventilating system, machinery must be used which can be regulated to move a given quantity of air in a given time for sure without guess-work under every condition of the exterior atmosphere. It will therefore be seen that the forced draft method of heating will be the proper means of heating for Schools, Churches, Theatres, Hospitals, and large public institutions.

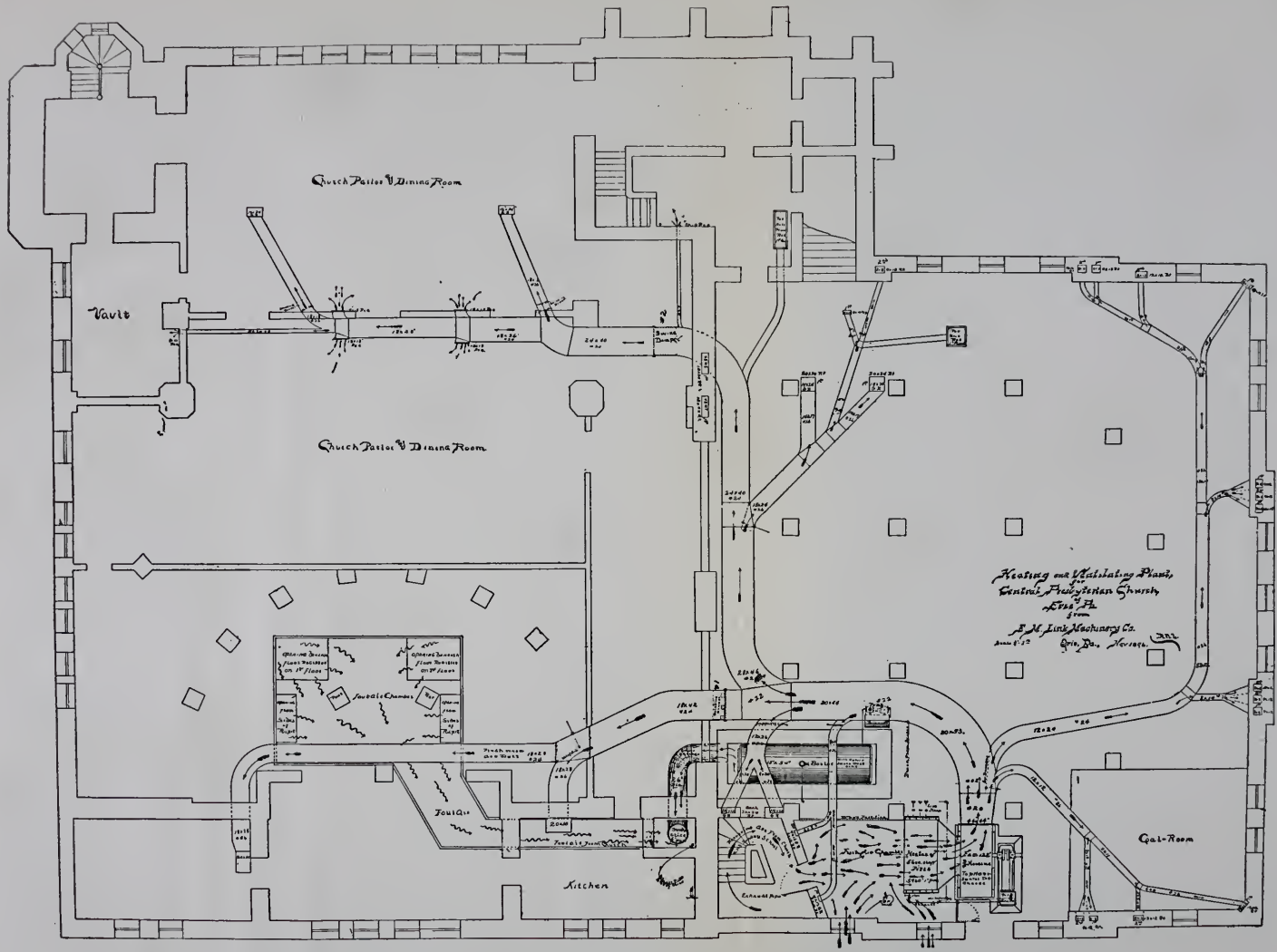
To arrange adequate ventilation in any building not specially planned for it is nearly always a difficult task. Many problems in connection with the ventilation of old buildings are now crowding themselves upon engineers, as the public becomes more and more impressed with the desirability of a

plentiful supply of pure outside air, both as a hygienic provision and as a luxury that well repays its cost. In many cases a really good and adequate system is impracticable for old buildings, either from structural or financial limitations, or perhaps both. In such cases the most that can be hoped for is a certain degree of improvement, depending upon the peculiar circumstances of the case. However, engineers fully imbued with the spirit of their profession are not averse to attacking difficult problems, and many an engineer's makeshift has resulted from their effort to give improved ventilation to buildings in the planning of which the idea of good ventilation had no part. To install the fan system of heating and ventilation successfully in an old building or one which has been erected and provided only with a system of direct heating, is an undertaking which entails usually a vast amount of planning and engineering to avoid cutting the building and exposing unsightly ducts to view. The following diagrams, Figs. 215 and 216, will give one a general idea of a carefully studied system arranged and installed in the Central Presbyterian Church and Sunday-school, Erie, Pa. The Sunday-school is an addition built on the church within the last two years, and is provided with proper flues for the ingress of pure air warmed to a comfortable degree, and the egress of foul air to the attic from which it escapes through suitable openings out into the atmosphere.

The heating of the church is accomplished by bringing up a 24″ x 40″ galvanized vertical flue or riser in the rear on each side of the pulpit. At the outlet of these risers is placed a special ornamental wrought-iron grille having a harp in the center surrounded by myrtle leaves through which the air passes into the church. These grilles are 30″ x 40″, with crown top and electroplated in silver and bronze, making an attractive and beautiful ornament, and at the same time, performing an important function in the general system.

The vertical risers are all encased in matched hard-wood and present a pleasing and unobjectionable appearance. The two 24″ x 36″ risers at the rear of the church are brought up from the basement between the partition as shown on first-floor plan, so that only the grilles of the system are noticed in the church auditorium.

The ventilation of the church is secured through two ornamental screens, each having a cross sectional area of 16 square feet, one each side of the rostrum, beneath which is the foul-air gathering chamber, with duct



CENTRAL PRESBYTERIAN CHURCH AND SUNDAY SCHOOL, ERIE, PA.—BASEMENT PLAN

FIG. 215

in basement connected to the vent shaft. In this vent shaft is located the smoke stack. (See plan of basement.) The pressure of the air forced into the church by the fan, together with the suction draft produced in the ventilating shaft by the smoke stack, accomplishes the ventilating part of the system perfectly.

Before the congregation arrives, the air in the church and Sunday-school is drawn down to the basement and through a series of heating coils (by a fan) raising the temperature to 140° F. This hot air is then forced through properly proportioned air distributing ducts in the bases of the vertical risers through which it passes into the various parts of the building. This re-circulatory movement of the air in the building is continued until the congregration is seated. The door of the fresh-air room communicating to the first floor is then closed, shutting off air from the building, and the two windows are opened in the basement, admitting pure fresh air from the outside, which is drawn through the apparatus and forced into the building, whence it escapes through the vent ducts.

The vertical risers for heating and ventilating the Sunday-school are made of galvanized iron, covered with thick asbestos covering, and built in the walls when building was being erected. This covering reduces the loss of heat radiation to a minimum.

All of the ducts are made rectangular in form, and, where they are not run between joists, are painted to harmonize with the paint in the rooms through which they pass.

Dampers are provided in the air ducts, so that either the church or the Sunday-school can be heated separately or combined.

On account of avoiding posts and economizing space, the engine (9 x 12) was provided with an extended crank shaft which carries the fan wheel; by exercising care in the lining up and placing of apparatus on the foundations, no noise is occasioned by this direct attached arrangement.

The heater is composed of five sections of 160 pipes in each section, equaling a total of 5,960 lineal feet of 1″ pipe; four sections in three compartments are arranged with valves for live steam at 20 lbs. pressure, and the fifth section is provided with a three-way valve to turn exhaust steam from the fan engine into this section in winter, and into the stack in the summer time. There are four rows of 1″ pipe 1′ long in each section, placed in a staggering manner so as to compel the passing air to come in contact with

every square inch of heating surface within the heater. The pipes are all of the same length, which insures equal steam travel, especially where exhaust steam is used, and the pipes all being screwed into the tapering base pieces vertically insures complete and perfect drainage.

The water of condensation from the live steam compartment flows into a trap which discharges it into a pump receiver from whence it is pumped automatically into the boiler.

In the exhaust pipe, between the engine and the exhaust compartment of heater, is placed a 3″ oil separator for eliminating the oil from the steam before it enters the heater.

The drain or bleeder pipes from this exhaust portion of the heater is provided with a four-foot hydrostatic seal between the heater and the receiver of the pump so that the pressure of the trap discharging condensation from the live steam compartment of the heater will not force the exhaust condensation back into the heater.

The pump receiver is provided with a vapor or relief pipe which is connected into the engine exhaust pipe at the rear of the back pressure valve.

This arrangement of piping permits saving all of the condensation from both the live and exhaust compartments of the heater.

The fan is three quarter housed (a portion of the blast wheel, which is 87″ dia. 41″ wide, travels in a brick pit two feet below the floor level) and delivers 30,000 cubic feet of air per minute, with the engine running at 170 revolutions. This amount of air changes the entire cubical contents of the building every 12 minutes, maintaining an excellent standard of pure air. The boiler is 54 x 15, of the standard tubular pattern and is 60 H. P. It has a return smoke flue over the top for superheating, which keeps the top of the boiler hot and saves a great amount of fuel. The boiler is provided with a dry pipe from which steam is taken to the heaters, engine and pump at a pressure of 20 lbs. per square inch. The boiler has a full flush ornamental front. It is supplied with a high and low water alarm column, safety and all other necessary valves complete.

The entire heating and ventilating system was designed, manufactured and installed by the E. M. Link Machinery Company, Inc., Erie, Pa.

In illustration, Fig, 217, we show a complete fan heating and ventilating apparatus set in position with fan, heater, engine, receiving tank, and pump,

* From "Heating and Ventilation."

and it will be seen that the floor space required for such an apparatus is small compared with the worked performed by such systems. The fresh air is usually brought from the exterior atmosphere to fans of this kind and then forced through the heating chamber or over the radiating surface, and shafts are constructed in many such cases through which the fresh air is taken from a point above the roof of the building, so that the air will be as free from dust as possible. To secure the full quantity of air at all times even when the heat is checked from the various rooms, or apartments, especially in schoolhouses, the fans are fitted with by-pass connections and which are operated by thermostatic regulations causing the cold air to mix with the warm air, which keeps the separate apartments to the desired temperature without decreasing the quantity of air delivered. Such systems of this kind have come under the observation of the writer, operate in a practically noiseless manner, and as they work under a steam pressure of from ten to twenty pounds per square inch, they are entirely safe from danger due to pressure. The same fan and engine is used in summer time for the purpose of cooling the building by forcing the same quantity of air through the various ducts as that which is forced through in cold weather, thus giving a pleasant degree of temperature with fresh air during the hottest exterior atmosphere.

Suggestions Relating to Air Distributing Ducts or Pipes Employed in Connection with a Forced Blast Heating and Ventilating Apparatus.

For Hot Blast Heating work the usual velocity for air in main duct is about 3,000 feet per minute, in branches about 1500 feet, in vertical flues 700 to 1,000 feet; discharge through registers from 500 to 600 feet.

After having determined the location and size of fan and heater for a given building, it is then necessary to consider the sizes, position and construction of the main distributing ducts and branches leading from the heating apparatus to the space to be heated and ventilated. In the most efficient "Fan" Heating Systems the main air duct, directly on leaving the mouth of the fan or the outlet of the heater (if the fan is to blow instead of exhaust through the heater) should be expanded from twenty-five per cent. to fifty per cent. over the area of the fan or heater outlet. Fifty per cent. will always be ample in the most extreme cases, but nothing short of twenty-five per cent. increased area over the outlet of heating apparatus is advisable. The object of this is to reduce the velocity of the air and to insure a large volume

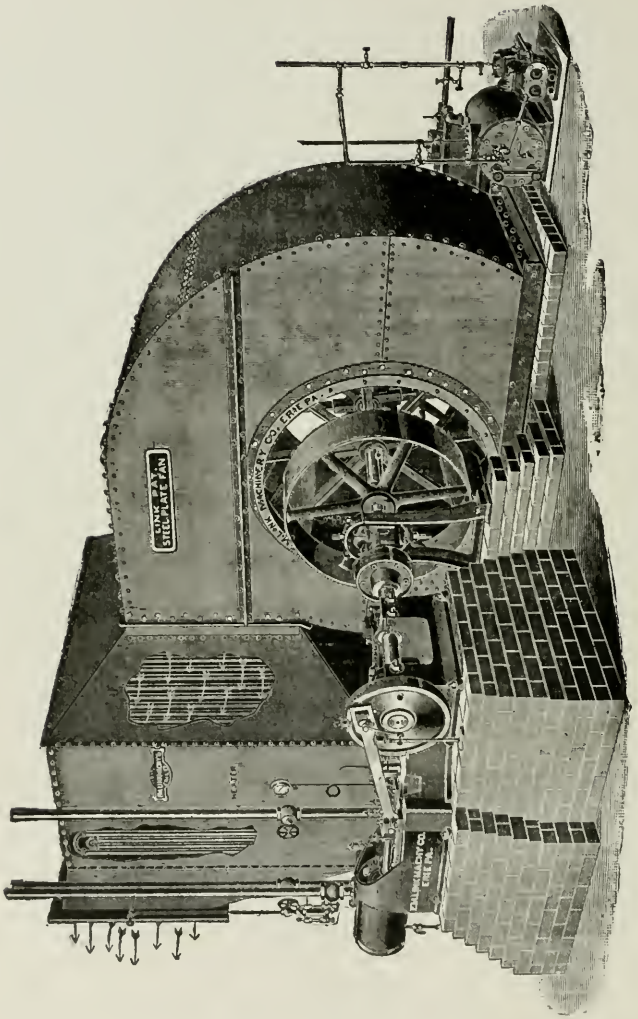


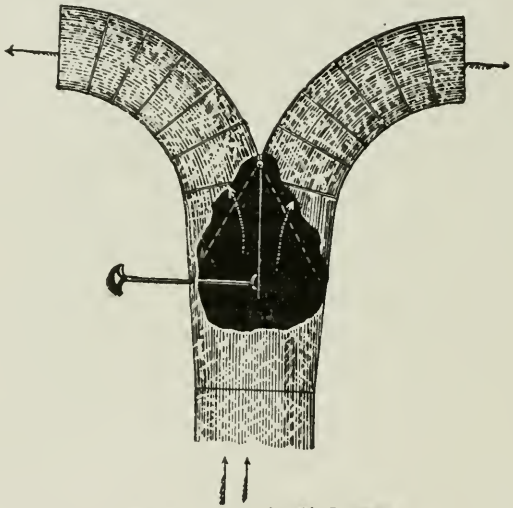
FIG. 217.

with the least possible resistance. When branches are taken from large main air ducts there is much less liability of inequalities in the results obtained at the different branch outlets, than there would be in taking the branches from small air pipes through which the air is passing at a high velocity. In such pipes, the natural tendency of air currents is to pass by the outlets and take a more direct or easier course. While it is not wholly impossible to successfully take out several branches from a duct through which air is passing at high velocity, and obtain nearly the same results in each branch, the finest point in constructing such to reach the desired end would be necessary. As branch pipes are taken from the main duct, this should be decreased in size, not in proportion to the area of the branch pipes taken therefrom, but in proportion to their frictional surfaces. By consulting tables on following pages, giving the necessary increase in diameter of pipes for handling the same amount of air at a given pressure through different lengths of pipe, it will be seen that, to properly lay out a system of air ducts, it should be first sketched on the plan and all sizes marked in, proportionate to their several duties and the relation between the different reductions of main pipes and branches made according to their frictional surfaces. The entire system may then be gone over and the proper corrections made for the different distances traveled.

The best material for main distributing pipes, as well as their branches, is galvanized iron, of proper gauge of different diameters as per following table, and their shape should be round whenever possible. Round pipe is more easily constructed, and has the largest effective area with a given perimeter of any known figure.

Where rectangular pipes have to be used the area should be increased at least 20 per cent. (25 per cent. is better) over that necessary for round pipe. Pipes should be made in lengths convenient to handle—say about ten feet each—having joints lapped nearly 2 inches in the direction of the air current. Joints should be riveted every 4 or 6 inches, and to insure their being tight ought to be soldered all the way round. Section ends may be provided with cast iron rings about $\frac{3}{8}$ of an thick, and from 1 to $1\frac{1}{2}$ inches wide, according to the diameter, so that the different ones can be easily put up or taken down. Elbows or curves should be made of from six to ten pieces, and have equal length in the throat, and the radius of all curves should be equal to four diam eters, measured from the center line of the elbow. Branch pipes when

taken from the main should always leave with a 45-degree elbow, and never be connected straight into it. When the branch is taken from the brick duct or metal pipe rectangular in shape, the reduction in size of the main flue should be made sidewise on the side from which branch is taken, keeping the opposite side of the flue straight. It will be seen when this is done that the currents of air are kept parallel, or in a straight line until divided. In making the "Y" branches or "T's," it is well to change the direction of the air pipe or duct before it reaches the "T," so that the direction of the air current will be proportionately divided by a "V" shape of the "T" or "Y" for their respective duties.



Damper for Equalizing Air Currents.
FIG. 218.

It is always desirable, when it is difficult to determine just which side the "Y" or "T" should be favored most, to construct in it a damper or equalizer, as here illustrated, Fig 218, in which may be adjusted after the apparatus has been started up. Such a damper is also useful for entirely closing off the current from any branch when heat is not desired in the rooms to which it leads.

TABLE OF CAPACITIES AT DIFFERENT PRESSURES AND VELOCITIES OF STEEL PLATE FANS.

PRESSURES AT OUTLETS.

Size of Fan	1 oz. Pres. 5,176 ft. per min.			3-4 oz. Pres., 4,483 ft. per min.			1-2 oz. Pres., 3,655 ft. per min.			1-4 oz. Pres 2,585 ft. per min.			Size of Fan
	Speed	H. P.	Capacity.	Speed	H. P.	Capacity.	Speed	H. P.	Capacity.	Speed	H. P.	Cap'y	
52	694	1.75	11,445	601	.97	9,905	493	.59	8,145	347	.19	5,725	52
61	651	2.5	16,115	563	1.5	13,955	663	.88	11,475	326	.35	8,065	61
73	510	3.25	25,885	442	2.	19,805	362	1.15	16,285	255	.51	11,445	73
82	427	4.4	30,165	370	2.5	26,105	304	1.5	21,465	214	.55	15,085	82
91	377	6.	39,005	326	3.4	33,755	267	2.	27,755	188	.73	19,505	91
101	341	9.5	48,365	295	5.5	41,855	243	3.	34,415	171	1.	24,185	101
112	308	12.	58,245	266	7.	50,405	218	4.	41,545	154	1.5	29,125	112
122	281	16.	69,685	244	9.	60,305	196	5.9	49,585	141	2.	34,845	122
131	264	18.	82,165	228	10.5	71,105	188	6.5	58,465	132	2.2	41,085	131
142	249	23.5	95,165	215	13.5	82,355	173	8.	67,715	125	2.8	47,585	142
153	228	29.5	109,205	197	17.	95,505	162	10.	77,705	111	3.5	54,605	153
161	210	42.	124,805	182	24.	108,005	150	14.5	88,805	105	5.	62,405	161
173	198	58.	140,925	172	33.5	121,955	141	20.	100,275	99	7.	70,465	173
182	192	67.	158,085	166	38.5	136,805	137	23.	112,485	96	8.	79,045	182

TABLE OF NECESSARY INCREASE IN DIAMETER OF AIR DUCTS FOR DIFFERENT LENGTHS.

By reference to the following table, it will be seen that the diameter of pipe for transmitting air from one point to another, changes with the distance air is to be carried.

This necessary increase is due to the fact that air in moving through ducts, a portion of its force is retarded by the friction of its particles along the sides of the ducts. The loss of pressure from this source increases directly according to the distance or length of the pipe, also the square of the velocity of moving air. *A Fan is oftentimes condemned as being insufficient* on account of the pipe connections beng improperly proportioned.

This table, which shows the proper increase in diameter for the different lengths, is practical, and experience has proven its value.

Diameter of Fan Outlet, in Inches.	30 ft pipe	60 ft pipe	90 ft pipe	120 ft pipe	150 ft pipe	180 ft pipe	210 ft pipe	240 ft pipe	270 ft pipe	300 ft. pipe.
	Diameter Pipe Should be	Diameter Pipe Should be	Diameter Pipe Should be	Diameter Pipe Should be	Diameter Pipe Should be	Diameter Pipe Should be	Diameter Pipe Should be	Diameter Pipe Should be	Diameter Pipe Should be	Diam. pipe Should be.
3	3¼	3⅜	4	4¼	4½	4¾	5	5¼	5⅝	5¼
3½	3¾	4¼	4½	4⅞	5	5¼	5½	5⅜	5¾	6½
4	4⅜	4¾	5⅛	5⅜	5¾	6	6¼	6½	6¾	7
4½	5	5⅜	5¾	6	6⅜	6¾	7	7¼	7½	7¾
5	5½	6	6⅜	6¾	7¼	7½	7¾	8⅜	8¾	8¾
6	6¼	7	7⅜	8	8½	9	9⅜	9¾	10¼	10½
7	7⅜	8¼	8¾	9⅜	10	10⅜	10¾	11¼	12¼	12⅜
8	8¾	9½	10⅛	10⅝	11⅛	11⅝	12⅜	12⅞	13⅜	14
9	10	10⅜	11½	12⅛	12¾	13⅜	14	14½	15½	15⅜
10	11	11⅝	12⅜	13½	14¼	14¾	15½	16⅛	16⅝	17⅜
11	12	13	13¾	14⅜	15⅜	16⅜	17⅛	17¾	18½	19½
12	13½	14¼	15¼	16⅛	17	17⅞	18⅜	19⅜	20¼	20¾
13	14½	15⅜	16½	17½	18⅜	19¼	20½	21	21⅝	22⅜
14	15⅜	16⅝	17⅞	18¾	19⅝	20⅜	21⅜	22⅜	23½	24½
15	16½	17⅜	19	20½	21½	22½	23½	24½	25⅜	26
16	17⅜	19	20⅜	21½	22⅜	23⅜	24½	25⅝	26⅞	27⅜
17	17⅜	20¼	21½	22⅜	24	25¼	26⅜	27½	28½	29½
18	19⅜	21⅜	22⅜	24¼	25½	26⅜	27⅜	29¼	30½	31½
19	20¼	22¼	24	25½	27	28¼	29½	30⅝	31⅞	33
20	22	23⅜	25⅜	27⅞	28⅜	29⅜	31	32¼	33½	34⅜
21	23	24⅞	26⅜	28¼	29⅜	31½	32½	33¾	35½	36⅜
22	24½	26¼	27⅞	29½	31¼	32⅜	34½	35½	36⅞	38¼
23	25½	27½	29½	30⅞	32½	34¼	35⅜	37¼	38½	39¾
24	26½	28½	30⅜	32½	34	35⅝	37½	38⅜	40½	41⅜
Length of mouth piece.	9 in.	15 in.	21 in.	27 in.	33 in.	39 in.	42 in.	48 in.	54 in.	60 in.

Table Giving Diameter of Air Ducts for Various Velocities.

Note.—To assist in determining the proper size of Air Ducts or Pipes required to deliver from 100 to 50,000 cubic feet of air at different pressures per square inch, and at different velocities in feet per minute, we append below a very convenient and reliable table.

Cubic Feet Air per Minute.	$\frac{1}{32}$ Oz. Pressure.	$\frac{1}{16}$ Oz. Pressure.	$\frac{1}{8}$ Oz. Pressure.	$\frac{1}{4}$ Oz. Pressure.	$\frac{1}{2}$ Oz. Pressure.	$\frac{3}{4}$ Oz. Pressure.	1 Oz. Pressure.
	Velocity 660 Feet per Min.	Velocity 930 Feet per Min.	Velocity 1320 Feet per Min.	Velocity 2580 Feet per Min.	Velocity 3654 Feet per Min.	Velocity 4482 Feet per Min.	Velocity 5175 Feet per Min.
	Diameters of Pipe, in Inches						
100	5.3	4.5	3.8	2.7	2.3	2.	1.9
200	7.5	6.4	5.3	3.8	3.2	2.9	2.7
300	9.2	7.7	6.5	4.7	3.9	3.6	3.3
400	10.6	9.	7.5	5.4	4.5	4.1	3.8
500	11.8	10.1	8.4	6.	5.1	4.6	4.3
600	12.6	11.1	9.2	6.6	5.5	5.	4.7
700	14.	11.9	9.9	7.1	6.	5.4	5.
800	15.	13.	10.6	7.6	6.4	5.8	5.4
900	15.9	13.4	11.3	8.	6.8	6.1	5.7
1000	16.7	14.1	11.8	8.5	7.1	6.4	6.
1250	18.8	15.8	13.2	9.5	8.	7.2	6.7
1500	20.5	17.2	14.5	10.4	8.7	7.9	7.4
1750	22.3	18.6	15.6	11.2	9.4	8.5	7.9
2000	23.6	20.	16.7	12.	10.1	9.1	8.6
2500	26.6	22.3	18.7	13.4	11.3	10.5	9.4
3000	28.9	24.4	20.5	14.7	12.4	11.1	10.3
3500	32.	26.6	22.3	15.8	13.3	12.1	11.6
4000	33.4	28.	23.6	16.9	13.8	12.8	11.9
4500	35.4	29.7	25.1	17.9	15.1	13.6	12.7
5000	37.3	31.4	26.4	18.9	15.8	14.3	13.4
6000	40.9	34.4	28.9	20.7	17.4	15.7	14.6
7000	44.1	37.1	31.2	22.3	18.8	17.	15.8
8000	47.2	39.7	33.4	23.9	20.1	18.1	16.9
9000	50.	42.2	35.4	25.3	21.3	19.2	17.9
10000	52.7	44.4	37.3	26.7	22.4	20.3	18.9
15000	64.6	54.3	45.7	32.7	27.4	24.8	23.1
20000	74.6	62.5	52.7	37.7	31.7	28.6	26.6
25000	84.	70.2	59.	42.2	35.5	32.	29.8
30000	91.3	76.9	64.6	46.2	38.8	35.1	32.6
35000	98.6	83.	69.8	49.8	41.8	37.9	35.2
40000	105.5	88.2	74.6	53.3	43.6	40.5	37.7
50000	118.	99.3	83.4	59.6	50.1	45.3	42.1

TABLE FOR EQUALIZING THE DIAMETER OF AIR DUCTS.

The lengths of pipes being equal, the small figures at the intersection of the horizontal with the vertical line, give the number of branch pipes (of the size shown in large figures at top of each column) that will convey the same amount of air as those shown in column designated "Diameter of Main Blast Pipe."

For example: It will require eleven branch pipes, 6 ins. in diameter to equal the capacity of one 16 ins, in diameter.

Some are liable to think that because the combined area of four 2-in. pipes is equal to one 4-in., the four pipes will convey the same quantity of air the same distance, with the same ease and freedom that the one 4-in. will, whereas it actually requires 5.7 say 6 pipes. This is due to an excess of friction for every cubic foot of air in the small pipes over that in the large. Parties putting in air pipes should extend the main pipes so as to make the branch pipes as short as possible.

For larger pipes use same proportions.

Diameter of Main Blast Pipe in Inches	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	24	26	28	30	36	42	46	54	60
2	2																												
3	2.7	3																											
4	6.7	2.0	4																										
5	9.8	3.6	1.8	5																									
6	16	5.7	2.8	1.6	6																								
7	23	8.3	4.1	2.3	1.5	7																							
8	32	12	5.7	3.2	2.1	1.4	8																						
9	42	16	7.6	4.3	2.8	1.9	1.3	9																					
10	56	20	9.9	5.7	3.6	2.4	1.7	1.3	10																				
11	71	26	12	7.0	4.5	3.1	2.2	1.7	1.3	11																			
12	88	32	16	9.0	5.7	3.8	2.8	2.0	1.6	1.2	12																		
13	107	39	19	11	6.9	4.7	3.4	2.5	1.9	1.5	1.2	13																	
14	129	47	23	13	8.3	5.7	4.1	3.0	2.3	1.8	1.5	1.2	14																
15	152	56	27	16	9.9	6.7	4.8	3.6	2.8	2.2	1.8	1.4	1.2	15															
16	180	65	32	18	11	7.9	5.7	4.2	3.2	2.6	2.1	1.7	1.4	1.2	16														
17	208	76	37	21	13	9.2	6.6	4.9	3.8	2.9	2.4	2.0	1.6	1.4	1.2	17													
18	239	88	43	24	16	10	7.7	5.7	4.3	3.4	2.8	2.3	1.9	1.6	1.3	1.2	18												
19	275	100	49	28	18	12	8.6	6.5	5.0	3.9	3.2	2.6	2.2	1.8	1.5	1.3	1.2	19											
20	313	114	56	32	20	14	9.9	7.4	5.7	4.5	3.6	2.9	2.5	2.1	1.7	1.5	1.3	1.4	20										
22	398	145	71	41	26	18	13	9.3	7.2	5.7	4.5	3.7	3.1	2.6	2.2	1.9	1.7	1.4	1.3	22									
24	493	180	88	50	32	22	16	12	8.9	7.6	5.7	4.6	3.8	3.2	2.9	2.4	2.1	1.8	1.6	1.2	24								
26	605	219	108	62	39	27	19	14	11	8.6	6.9	5.7	4.7	4.0	3.4	2.9	2.5	2.2	1.9	1.5	1.2	26							
28	725	265	129	74	48	32	23	17	13	10	8.3	6.8	5.7	4.8	4.1	3.5	3.0	2.6	2.3	1.8	1.5	1.2	28						
30	864	315	154	88	56	38	28	20	16	12	9.9	8.0	6.7	5.7	4.7	4.1	3.6	3.0	2.6	2.2	1.7	1.4	1.2	30					
38	1361	497	243	139	88	60	43	32	25	19	16	13	11	8.9	7.6	6.5	5.7	5.0	4.3	3.4	2.7	2.2	1.9	1.6	36				
42	2000	730	358	205	129	88	63	47	36	29	23	19	16	13	11	9.6	8.5	7.3	6.4	5.0	4.1	3.3	2.8	2.3	1.5	42			
46	2792	1081	492	282	180	123	88	66	50	39	32	26	22	18	16	13	12	10	8.9	7.0	5.7	4.7	3.8	3.2	2.1	1.4	46		
54	3753	1368	671	384	244	166	119	88	68	53	43	35	29	24	21	18	16	15	12	9.4	7.6	6.2	5.2	4.3	2.8	1.9	1.3	54	
60	4679	1781	872	499	314	215	154	115	88	69	56	46	38	32	27	23	20	18	16	12	9.9	8.1	6.7	5.7	3.6	2.4	1.8	1.3	60

TABLE OF LOSS OF HEAT FROM EXPOSED STEAM PIPES, WITH RELATIVE VALUE OF COVERINGS.—TABLE OF NON-CONDUCTING POWER OF DIFFERENT SUBSTANCES.

The loss by radiation from exposed steam pipes is considerable, and in the case of pipes leading to steam engines, it is magnified by the action of the condensed water in the cylinder; it is, therefore, important that pipes carrying either live or exhaust steam to the apparatus should be well protected. The following table gives the loss of heat from steam pipes, naked and clothed with wool or hair felt, of different thickness, the steam pressure being assumed at 75 lbs. and the extreme air at 60°. There is a wide difference in the value of different substances for protection from radiation, their value varying nearly in the inverse ratio of their conducting power for heat, up to their ability to transmit as much heat as the surface of the pipe will radiate, after which they become detrimental, rather than useful, as covering.

Hair or wool felt has the disadvantage of becoming soon charred from the heat of steam at high pressure, and sometimes of taking fire therefrom. This has led to the employment of a variety of "cements" for covering pipes—composed generally of clay mixed with different substances, as asbestos, paper fiber, charcoal, etc. A series of careful experiments, made at Massachusetts Institute of Technology, showed the condensation of steam in a pipe covered by one of them, as compared with a naked pipe, and one clothed with hair felt, was 100 for the naked pipe, 67 for the "cement" covering, and 27 for the hair felt.

TABLE OF LOSS OF HEAT FROM STEAM PIPES.

Thickness of Covering in Inches.	Outside Diameter of Pipe, without Felt.														
	2-in. Diameter.			4-in. Diameter.			6-in. Diameter.			8-in. Diameter.			12-in. Diameter.		
	Loss in Units per Foot Run per Hour.	Ratio of Loss.	Feet in Length per H. P. lost.	Loss in Units per Foot Run per Hour.	Ratio of Loss.	Feet in Length per H. P. lost.	Loss in Units per Foot Run per Hour.	Ratio of Loss.	Feet in Length per H. P. lost.	Loss in Units per Foot Run per Hour.	Ratio of Loss.	Feet in Length per H. P. lost.	Loss in Units per Foot Run per Hour.	Ratio of Loss.	Feet in Length per H. P. lost.
0	219.0	1.00	132	390.8	1.00	75	624.1	1.000	46	729.8	1.000	40	1077.4	1.000	26
¼	100.7	.46	288	180.9	.46	160									
½	65.7	.30	441	117.2	.30	247	187.2	.300	154	219.6	.301	132	301.7	.280	92
1	43.8	.20	662	73.9	.18	392	111.0	.178	261	128.3	.176	225	185.3	.172	157
2	28.4	.13	1020	44.7	.11	648	66.2	.106	438	75.2	.103	385	98.0	.091	294
4	19.8	.09	1464	28.1	.07	1031	41.2	.066	703	46.0	.063	630	60.3	.056	486
6				23.4	.06	1238	33.7	.054	869	34.3	.047	845	45.2	.042	642

TABLE OF RELATIVE VALUE OF NON-CONDUCTORS.
(FROM CHAS. E. EMERY, PH. D.)

Non-Conductor	Value	Non-Conductor	Value
Wool Felt	1.000	Loam, dry and open	.550
Mineral wool, No. 2	.832	Slacked Lime	.480
" with tar	.715	Gas House carbon	.470
Sawdust	.680	Asbestos	.363
Mineral wool, No. 1	.676	Coal Ashes	.345
Charcoal	.632	Coke in Lumps	.277
Pine wood across fiber	.553	Air space undivided	.163

TABLE OF CONDUCTING POWER OF VARIOUS SUBSTANCES.
(FROM PECLET.)

Substance	Conducting Power	Substance	Conducting Power
Blotting paper	.274	Wood across fiber	.83
Eiderdown	.314	Cork	1.15
Cotton or wool { any density	.323	Coke, pulverized	1.29
Wood Ashes	.531	India Rubber	1.37
Hemp canvas	.418	Wood, with fiber	1.40
Mahogany dust	.523	Plaster of Paris	3.86
Straw	.563	Baked clay	4.33
Charcoal powder	.636	Glass	6.6
		Stone	13.68

TABLE OF THE NUMBER OF CUBIC FEET OF AIR THAT MAY BE HEATED THROUGH 1° F. BY THE CONDENSATION OF ONE POUND OF STEAM, AND THE COOLING OF THE WATER OF CONDENSATION TO 112° F.

Steam Pressure above Vacuum.	Temperature of Air.										
	0°	12°	22°	32°	42°	52°	62°	72°	82°	92°	102°
15	46,872	48,224	49,277	50,320	51,335	52,330	53,362	54,358	55,402	56,397	57,430
25	47,270	48,634	49,636	50,748	51,783	52,775	53,817	54,820	55,863	56,876	57,919
35	47,551	48,927	49,995	51,054	52,083	53,092	54,141	55,150	56,199	57,218	58,267
45	47,777	49,157	50,230	51,294	52,329	53,343	54,396	55,411	56,564	57,488	58,541
55	47,965	49,349	50,327	51,494	52,531	53,550	54,608	55,528	56,684	57,712	58,770
65	48,126	49,515	50,596	51,667	52,709	53,730	54,792	55,813	56,875	57,906	58,968
75	48,268	49,661	50,745	51,819	52,864	53,889	54,953	55,978	57,042	58,077	59,141
85	48,396	49,793	50,879	51,957	53,004	54,031	55,099	56,126	57,193	58,231	59,298
95	48,512	49,912	51,002	52,094	53,132	54,161	55,231	56,261	57,331	58,371	59,441
105	48,662	50,066	51,159	52,243	53,296	54,329	55,402	56,435	57,508	58,551	59,624
Per cent. of above amounts that will be heated 1° if the air is saturated.	99.8	99.6	99.4	99.0	98.6	98.0	97.1	96.0	94.5	92.5	90.1

Fuel.

The value of any fuel is measured by the number of heat units which its combustion will generate, a unit of heat being the amount required to heat one pound of water one degree Fahrenheit. The fuel used in generating steam is composed of carbon and hydrogen, and ash, with sometimes small quantities of other substances not materially affecting its value.

"Combustible" is that portion which will burn; the ash or residue varying from 2 to 36 per cent. in different fuels.

TABLE OF COMBUSTIBLES.

Kind of Combustible.	Air Required	Temperature of Combustion.				Theoretical Value.		Highest Attainable Value under Boiler.	
	In Pounds per pound of Combustible.	With Theoretical Supply of Air.	With 1½ Times the Theoretical Supply of Air.	With Twice the Theoretical Supply of Air.	With Three Times the Theoretical Supply of Air.	In Pounds of Water raised 1° per pound of Combustible.	In Pounds of Water evaporated from & at 212°, with 1 lb. Combustible.	With Chimney Draft.	With Blast, Theoretical supply of Air at 60°, Gas 350°
Hydrogen	36.00	5750	3860	2860	1940	62032	64.20		
Petroleum	15.43	5050	3515	2710	1850	21000	21.74	18.55	19.90
Carbon { Charcoal, Coke, Anthracite Coal, }	12.13	4580	3215	2440	1650	14500	15.00	13.30	14.14
Coal—Cumberland	12.06	4900	3360	2550	1730	15370	15.90	14.28	15.06
" Coking Bituminous	11.73	5140	3520	2680	1810	15837	16.00	14.45	15.19
" Cannel	11.80	4850	3330	2540	1720	15080	15.60	14.01	14.76
" Lignite	9.30	4600	3210	2490	1670	11745	12.15	10.78	11.46
Peat—Kiln dried	7.68	4470	3140	2420	1660	9660	10.00	8.92	9.42
" Air dried 25 per cent. water	5.76	4000	2820	2240	1550	7000	7.25	6.41	6.78
Wood—Kiln dried	6.00	4080	2910	2260	1530	7245	7.50	6.64	7.02
" Air dried 20 per cent. water	4.80	3700	2607	2100	1490	5600	5.80	4.08	4.39

There is a large difference in coals from different localities, and even adjacent mines. The following table of American coals, is compiled from various sources:

AMERICAN COALS.

Coal.	Per cent. of Ash.	Theoretical Value		Coal.	Per cent. of Ash	Theoretical Value	
State. Kind of Coal.		in Heat Units.	Pounds of water evap.	State. Kind of Coal.		in Heat Units.	Pounds of water evap.
Penn. Anthracite	3.49	14,199	14.70	Ill. Bureau Co	5.20	13,025	13.48
" "	6.13	13,535	14.01	" Mercer Co	5.60	13,123	13.58
" "	2.90	14,221	14.72	" Montauk	5.50	12,659	13.10
" Cannel	15.02	13,143	13.60	Ind. Block	2.50	13,588	14.38
" Connelsville	6.50	13,368	13.84	" Caking	5.66	14,146	14.04
" Semi.bit'nous	10.79	13,155	13.62	" Cannel	6.00	13,097	13.56
" Stone's Gas	5.00	14,021	14.51	Md. Cumberland	13.88	12,226	12.65
" Youghiogheny	5.60	14,265	14.76	Ark. Lignite	5.00	9,315	19.54
" Brown	9.50	12,324	12.75	Col. "	9.25	13,562	14.04
Kentucky Caking	2.75	14,391	14.89	" "	4.50	13,866	14.35
" Cannel	2.00	15,198	16.76	Texas "	4.50	12,962	13.41
" "	14.80	13,360	13.84	Wash. Ter. Lignite	3.40	11,551	11.96
" Lignite	7.00	9.326	9.65	Penn. Petroleum		20,746	21.47

The effective value of all kinds of wood *per pound*, when dry, is substantially the same. This is usually estimated at 0.4 the value of the same weight of coal. The following are the weights and comparative value of different woods by the cord:

Kind of Wood.	Weight.	Kind of Wood.	Weight.
Hickory, Shell bark	4469	Beech	3126
" Red heart	3705	Hard Maple	2878
White Oak	3821	Southern Pine	3375
Red Oak	3254	Virginia "	2680
Spruce	2325	Yellow "	1994
New Jersey Pine	2137	White "	1868

The first table gives for the more common combustibles, the air required for complete combustion, the temperature with different proportions of air, the theoretical value, and the highest attainable value under a steam boiler, assuming that the gases pass off at 3290, the temperature of steam at 75 lbs. pressure, and the incoming draft to be at 600; also that with chimney draft twice and with blast only the theoretical amount of air is required for combustion.

Temperature of Fire.

By reference to the table of combustibles, it will be seen that the temperature of the fire is nearly the same for all kinds of combustibles, under similar conditions. If the temperature is known, the conditions of combustion may be inferred. The following table, from M. Pouillet, will enable the temperature to be judged by the appearance of the fire:

Appearance.	Temp. Fah.	Appearance.	Temp. Fah.
Red, just visible	977°	Orange, deep	2010
" dull	1290	" clear	2190
" Cherry, dull	1470	White heat	2370
" " full	1650	" bright	2550
" " clear	1830	" dazzling	2730

To determine temperature by fusion of metals, etc.—

Substance.	Temp. Fah.	Metal.	Temp. Fah.	Metal.	Temp. Fah.
Tallow	92°	Bismuth	518	Silver, pure	1830
Spermaceti	120	Lead	630	Gold Coin	2156
Wax, white	154	Zinc	793	Iron Cast, med	2010
Sulphur	239	Antimony	810	Steel	2550
Tin	455	Brass	1650	Wrought Iron	2910

Horse-Power of Boilers.

Strictly speaking, there is no such thing as "horse-power" to a steam boiler; it is a measure applicable only to dynamic effect. But as boilers are necessary to drive steam-engines, the same measure applied to steam-engines has come to be universally applied to the boiler, and cannot well be discarded. In consequence, however, of the different quantity of steam necessary to produce a horse-power, with different engines, there has been great need of an accepted standard by which the amount of boiler required to provide steam for a commercial horse-power may be determined.

This standard, as fixed by Watt, was one cubic foot of water evaporated per hour from 212° for each horse-power. This was, at that time, the requirement of the best engine in use. At the present time, Prof. Thurston estimates, that the water required per hour, per horse-power, in good engines, is equal to the constant 200, divided by the square root of the pressure, and that in the best engines this constant is as low as 150. This would give for good engines, working with 64 lbs. pressure, 25 lbs. water, and for the best engines working with 100 lbs., only 15 lbs. water per hourly horse-power.

The extensive series of experiments, made under the direction of C. E. Emery, M. E., at the Novelty Works, in 1866–8, and published by Professor Trowbridge, show, that at ordinary pressures, and with good proportions, non-condensing engines of from 20 to 300 H. P., required only from 25 to 30 lbs. water per hourly horse-power, in regular practise.

The standard, therefore, adopted by the judges at the late Centennial Exhibition, of 30 lbs. water per hour, evaporated, at 70 lbs. pressure, from 100°, for each horse-power, is a fair one for both boilers and engines, and has been favorably received by the Am. Soc. of Mech. Engineers and by steam users, but as the same boiler may be made to do more or less work with less or greater economy, it should be also required that the rating of a boiler be based on the amount of water it will evaporate at a high economical rate.

For purposes of economy the amount of heating surface should never be less than one, and generally not more than two, square feet, for each 5,000 British thermal units to be absorbed per hour, though this depends somewhat on the character and location of such surface. The range given above is believed to be sufficient to allow for the different conditions in practise, though a far greater range is frequently employed. As, for instance, in torpedo boats, where everything is sacrificed to lightness and power, the

heating surface is sometimes made to absorb 12,000 to 15,000 B. T. U. per square foot per hour, while in some mills, where the proprietor and his advisers have gone on the principle that "too much is just enough," a square foot is only required to absorb 1,000 units or less per hour. Neither extreme is good economy.

Square feet of heating surface is no criterion as between different styles of boilers—a square foot under some circumstances being many times as efficient as in others; but when an average rate of evaporation per square foot for any given boiler has been fixed upon by experiment, there is no more convenient way of rating the power of others of the same style. The following table gives an approximate list of square feet of heating surface per H. P. in different styles of boilers; and various other data for comparison:

Type of Boiler.	Square feet of Heating surface for One H. P.	Coal per sq. ft. H. S. per hour.	Relative Economy.	Relative Rapidity of Steaming.	Authority.
Water-tube	10 to 12	.3	1.00	1.00	Isherwood.
Tubular	14 to 18	.25	.91	.50	"
Flue	8 to 12	.4	.79	.25	
Plain Cylinder	6 to 10	.5	.69	.20	Prof. Trowbridge.
Locomotive	12 to 16	.275	.85	.55	
Vertical Tubular	15 to 20	.25	.80	.60	

A horse-power in a steam-engine or other prime mover, is 550 lbs. raised 1 foot per second or 33,000 lbs. 1 foot per minute.

Horse-Power of Different Nations.

Most nations have a standard for power similar to, and generally derived from, Watt's "horse-power," but owing to different standards of weights and measures, these are not identical, though the greatest differences amount to less than 1½ per cent. The following table gives the standard horse-power for each nation, in *kilogrammeters per second*, and in *foot-pounds per second*, expressed in the foot and pound standard in each country:

TABLE OF STANDARD HORSE-POWER FOR DIFFERENT NATIONS.

Country.	Kilogrammeters per sec.	Baden Ft. pounds, per sec.	Saxon Ft. pounds, per sec.	Wurtemberg Ft. pounds, per sec.	Prussian Ft. pounds, per sec.	Hanoverian Ft. pounds, per sec.	English Ft. pounds, per sec.	Austrian Ft. pounds, per sec.
France and Baden	**75**	**500**	529.68	521.58	477.93	513.53	542.47	423.68
Saxony	75.045	500.30	**530**	523.89	478.22	513.84	542.80	423.93
Wurtemberg	75.240	501.36	531.12	**525.**	479.23	514.92	543.95	424.83
Prussia	75.325	502.17	531.97	525.85	**480.**	515.75	544.82	425.51
Hanover	75.361	502.41	532.23	526.10	480.23	**516.**	545.08	425.72
England	76.041	506.94	537.03	530.84	484.56	520.65	**550.**	429.56
Austria	76.119	507.46	437.58	531.39	485.06	521.19	550.57	**430.**

Weight and Volume of Air.

A cubic foot of air at 60° and under average atmospheric pressure, at sea level, weighs 536 grains, and 13.06 cubic feet weigh one pound. Air expands or contracts an equal amount with each degree of variation in temperature. Its weight and volume at any temperature under 30 inches of barometer may be found within less than one-half of one per cent.

Chimneys.

Chimneys are required for two purposes—1st, to carry off obnoxious gases; 2d, to produce a draught, and so facilitate combustion. The first requires size, the second height.

Each pound of coal burned yields from 13 to 30 pounds of gas, the volume of which varies with the temperature.

The weight of gas to be carried off by a chimney in a given time depends upon three things—size of chimney, velocity of flow, and density of gas. But as the density decreases directly as the absolute temperature, while the velocity increases, with a given height, nearly as the square root of the temperature, it follows that there is a temperature at which the weight of gas delivered is a maximum. This is about 550° above the surrounding air. Temperature, however, makes so little difference, that at 550° above, the quantity is *only four per cent.* greater than at 300°. Therefore, height and area are the only elements necessary to consider in an ordinary chimney.

The intensity of draught is, however, independent of the size, and depends upon the difference in weight of the outside and inside columns of air, which varies nearly as the product of the height into the difference of temperature. This is usually stated in an equivalent column of water, and may vary from 0 to possibly 2 inches.

After a height has been reached to produce draught of sufficient intensity to burn fine, hard coal, provided the area of the chimney is large enough, there seems no good mechanical reason for adding further to the height, whatever the size of the chimney required. Where cost is no consideration there is no objection to building as high as one pleases; but for the purely utilitarian purpose of steam-making, equally good results might be attained with a shorter chimney at much less cost.

The intensity of draft required varies with the kind and condition of the fuel, and the thickness of the fires. Wood requires the least, and fine coal or

slack the most. To burn anthracite slack to advantage, a draught of 1¼ inches of water is necessary, which can be attained by a well-proportioned chimney 185 feet high.

Generally a much less height than 100 feet cannot be recommended for a boiler, as the lower grades of fuel cannot be burned as they should be with a shorter chimney.

A round chimney is better than square, and a straight flue better than a tapering, though it may be either larger or smaller at top without detriment.

The effective area of a chimney for a given power, varies inversely as the square root of the height. The actual area, in practise, should be greater, because of retardation of velocity due to friction against the walls. On the basis that this is equal to a layer of air two inches thick over the whole interior surface, and that a commercial horse-power requires the consumption on an average of 5 pounds of coal per hour.

SIZES OF CHIMNEYS WITH APPROPRIATE HORSE-POWER BOILERS.

Dia. in inches.	Height of Chimneys.											Effective Area, square ft.	Actual Area, square ft.	Side of square of approximate area. Inches.
	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.	110 ft.	125 ft.	150 ft.	175 ft.	200 ft.			
	Commercial Horse-Power.													
18	23	25	27									0.97	1.77	16
21	35	38	41									1.47	2.41	19
24	49	54	58	62								2.08	3.14	22
27	65	72	78	83								2.78	3.98	24
30	84	92	100	107	113							3.58	4.91	27
33		115	125	133	141							4.47	5.94	30
36		141	152	163	173	182						5.47	7.07	32
39			183	196	208	219						6.57	8.30	35
42			216	231	245	258	271					7.76	9.62	38
48				311	330	348	365	389				10.44	12.57	43
54				363	427	449	472	503	551			13.51	15.90	48
60				505	539	565	593	632	692	748		16.98	19.64	54
66					658	694	728	776	849	918	981	20.83	23.76	59
72					792	835	876	934	1023	1105	1181	25.08	28.27	64
78						995	1038	1107	1212	1310	1400	29.73	33.18	70
84						1163	1214	1294	1418	1531	1637	34.76	38.48	75
90						1344	1415	1496	1639	1770	1893	40.19	44.18	80
96						1537	1616	1720	1876	2027	2167	46.01	50.27	86

Properties of Saturated Steam.

Ice is liquified and becomes water at 32° F. Above this point water increases in temperature up to the steaming point, nearly at the rate of 1° for each unit of heat added per pound of water. The steaming point (212° at atmospheric pressure), rises as the superimposed pressure increases, but at a

decreasing ratio; as, for example, at atmospheric pressure it takes $3\frac{1}{2}°$ to add a pound, while at 150 lbs. $\frac{1}{2}°$ gives the same increase of pressure.

For each unit of heat added above the steaming point, a portion of the water is converted into steam, having the same temperature and the same pressure as that at which it is evaporated. The heat so absorbed is called "Latent Heat." The amount of heat rendered latent by each pound of water in becoming steam varies at different pressures, decreasing as the pressure increases. This latent heat added to the sensible heat (or the thermometric temperature), constitutes the "Total Heat." The "total heat" being greater as the pressure increases, it will take more heat, and consequently more fuel, to make a pound of steam the higher the pressure.

Saturated steam cannot be cooled except by lowering its pressure, the abstraction of heat being compensated by the latent heat of a portion which is condensed. Neither can steam, in contact with water, be heated above the temperature normal to its pressure.

The density of saturated steam varies from $\frac{5}{8}$ that of air of same temperature and pressure, below that of the atmosphere, to $\frac{2}{3}$ at 100 lbs. Its weight per cubic foot varies as the 17 root of the 16th power, and may be found by the formula: $D = .003027p^{.941}$, which is correct to within $\frac{1}{7}$ per cent. up to 250 lbs. pressure.

The following table gives the properties of steam at different pressures—from 1 lb. to 500.

The gauge pressure is about 15 pounds (14.7) less than the total pressure, so that in using this table, 15 must be added to the pressure as given by the steam gauge. The column of Temperatures gives the thermometric temperature of steam and the boiling point at each pressure. The "factor of equivalent evaporation" shows the proportionate cost in heat or fuel of producing steam at the given pressure as compared with atmospheric pressure.

To ascertain the equivalent evaporation at any pressure, multiply the given evaporation by the factor of its pressure, and divide the product by the factor of the desired pressure.

Each degree of difference in temperature of feed-water makes a difference of .00104 in the amount of evaporation. Hence, to ascertain the equivalent evaporation from any other temperature of feed than 212°, add to the factor given as many times .00104 as the temperature of feed-water is degrees below 212°. For other pressures than those given in the table, it will be practically

correct to take the proportion of the difference between the nearest pressures given in the table.

TABLE OF PROPERTIES OF SATURATED STEAM, PARTLY FROM C. H. PEABODY'S TABLES.

Pressure in pounds per sq. in. above vacuum.	Temperature in degrees, Fahrenheit.	Total heat in heat units from water at 32°.	Heat in liquid from 32° in units.	Heat of vaporization, or latent heat in heat units.	Density or weight of cubic ft. in pounds.	Volume of one pound in cubic feet.	Factor of equivalent evaporation at 212°.	Total pressure above vacuum.
1	101.99	1113.1	70.0	1043.0	0.00299	334.5	.9661	1
2	126.27	1120.5	94.4	1026.1	0.00576	173.6	.9738	2
3	141.62	1125.1	109.8	1015.3	0.00844	118.5	.9786	3
4	153.09	1128.6	121.4	1007.2	0.01107	90.33	.9822	4
5	162.34	1131.5	130.7	1000.8	0.01366	73.21	.9852	5
6	170.14	1133.8	138.6	995.2	0.01622	61.65	.9876	6
7	176.90	1135.9	145.4	990.5	0.01874	53.39	.9897	7
8	182.92	1137.7	151.5	986.2	0.02125	47.06	.9916	8
9	188.33	1139.4	156.9	982.5	0.02374	42.12	.9934	9
10	193.25	1140.9	161.9	979.0	0.02621	38.15	.9949	10
15	213.03	1146.9	181.8	965.1	0.03826	26.14	1.0003	15
20	227.95	1151.5	196.9	954.6	0.05023	19.91	1.0051	20
25	240.04	1155.1	209.1	946.0	0.06199	16.13	1.0099	25
30	250.27	1158.3	219.4	938.9	0.07360	13.59	1.0129	30
35	259.19	1161.0	228.4	932.6	0.08508	11.75	1.0157	35
40	267.13	1163.4	236.4	927.0	0.09644	10.37	1.0182	40
45	274.29	1165.6	243.6	922.0	0.1077	9.285	1.0205	45
50	280.85	1167.6	250.2	917.4	0.1188	8.418	1.0225	50
55	286.89	1169.4	256.3	913.1	0.1299	7.698	1.0245	55
60	292.51	1171.2	261.9	909.3	0.1409	7.097	1.0263	60
65	297.77	1172.7	267.2	905.5	0.1519	6.583	1.0280	65
70	302.71	1174.3	272.2	902.1	0.1628	6.143	1.0295	70
75	307.38	1175.7	276.9	898.8	0.1736	5.760	1.0309	75
80	311.80	1177.0	281.4	895.6	0.1843	5.426	1.0323	80
85	316.02	1178.3	285.8	892.5	0.1951	5.126	1.0337	85
90	320.04	1179.6	290.0	889.6	0.2058	4.859	1.0350	90
95	323.89	1180.7	294.0	886.7	0.2165	4.619	1.0362	95
100	327.58	1181.9	297.9	884.0	0.2271	4.403	1.0374	100
105	331.13	1182.9	301.6	881.3	0.2378	4.205	1.0385	105
110	334.56	1184.0	305.2	878.8	0.2484	4.026	1.0396	110
115	337.86	1185.0	308.7	876.3	0.2589	3.862	1.0406	115
120	341.05	1186.0	312.0	874.0	0.2605	3.711	1.0416	120
125	344.13	1186.9	315.2	871.7	0.2800	3.571	1.0426	125
130	347.12	1187.8	318.4	869.4	0.2904	3.444	1.0435	130
140	352.85	1189.5	324.4	865.1	0.3113	3.212	1.0453	140
150	358.26	1191.2	330.0	861.2	0.3321	3.011	1.0470	150
160	363.40	1192.8	335.4	857.4	0.3530	2.833	1.0486	160
170	368.29	1194.3	340.5	853.8	0.3737	2.676	1.0502	170
180	372.97	1195.7	345.4	850.3	0.3945	2.535	1.0517	180
190	377.44	1197.1	350.1	847.0	0.4153	2.408	1.0531	190
200	381.73	1198.4	354.6	843.8	0.4359	2.294	1.0545	200
225	391.79	1201.4	365.1	836.3	0.4876	2.051	1.0576	225
250	400.99	1204.2	374.7	829.5	0.5393	1.854	1.0605	250
275	409.50	1206.8	383.6	823.2	0.5913	1.691	1.0632	275
300	417.42	1209.3	391.9	817.4	0.644	1.553	1.0657	300
325	424.82	1211.5	399.6	811.9	0.696	1.437	1.0680	325
350	431.90	1213.7	406.9	806.8	0.748	1.337	1.0703	350
375	438.40	1215.7	414.2	801.5	0.800	1.250	1.0724	375
400	445.15	1217.7	421.4	796.3	0.853	1.172	1.0745	400
500	466.57	1224.2	444.3	779.9	1.065	.939	1.0812	500

Heating Feed-Water.

The feed-water furnished to steam boilers has to be heated from the normal temperature to that of the steam before evaporation can commence, and this generally at the expense of the fuel which should be utilized in making steam. This temperature at 75 lb. pressure is 320°, and if we take 60° as the average temperature of feed, we have 260 units of heat per pound, which, as it takes 1,151 units to evaporate a pound from 60°, represents 22.5 per cent. of the fuel. All of this heat, therefore, which can be imparted to the feed-water is just so much saved, not only in cost of fuel, but in capacity of boiler. But it is essential that it be done by heat which would otherwise be wasted. All heat imparted to feed-water by injectors and "live-steam heaters" comes from the fuel and represents no saving.

There are two sources of waste heat available for this purpose—exhaust steam and chimney gases. By the former, water may be heated to 200°, or possibly to 210°, in a well-proportioned heater.

The gases going to the chimney carry off on an average, according to good authority, 51 per cent. of the fuel, and in the most economical boiler this cannot be reduced below 12 per cent. Some proportion of this is always available for heating the feed-water, by what are known as "economizers," and frequently it may be carried nearly to the temperature of high pressure steam, making a saving in some instances of 20 per cent. The more wasteful the boiler, the greater the benefit of the economizer; but for large plants it is always a valuable adjunct. In many cases water heated by exhaust steam may be still further heated in an economizer to advantage.

SAVING OF FUEL BY HEATING FEED-WATER. (IN PER CENT., STEAM AT SIXTY POUNDS.)

Initial Tem. of Water	Final Temperature of Feed-Water.						
	120	t 140	160	180	200	250	300
32°	7.50	9.20	10.90	12.36	14.30	19.03	22.90
35	7.25	8.96	10.66	12.09	14.09	18.34	22.60
40	6.85	8.57	10.28	12.00	13.71	17.99	22.27
45	6.45	8.17	9.90	11.61	13.34	17.64	21.94
50	6.05	7.71	9.50	11.23	13.00	17.28	21.61
55	5.64	7.37	9.06	10.85	13.60	16.93	21.27
60	5.23	6.97	8.72	10.46	12.20	16.58	20.92
65	4.82	6.56	8.32	10.07	11.82	16.20	20.58
70	4.40	6.15	7.91	9.68	11.43	15.83	20.23
75	3.98	5.74	7.50	9.28	11.04	15.46	19.88
80	3.55	5.32	7.09	8.87	10.65	15.08	19.52
85	3.12	4.90	6.63	8.46	10.25	14.70	19.17
90	2.68	4.47	6.26	8.06	9.85	14.32	18.81
95	2.24	4.04	5.84	7.65	9.44	13.94	18.44
100	1.80	3.61	5.42	7.23	9.03	13.55	18.07
110	.90	2.73	4.55	6.38	8.20	12.76	17.28
120	0	1.84	3.67	5.52	7.36	11.95	16.49
130		.92	2.77	4.64	6.99	11.14	15.24
140		0	1.87	3.75	5.62	10.31	14.99
150			.94	2.83	4.72	9.46	14.18
160			0	1.91	3.82	8.59	13.37
170				.96	2.89	7.71	12.54
180				0	1.96	6.81	11.70
200					0	4.85	9.93

OFFICIAL SCHEDULE OF UNIFORM STANDARD FLANGES.

Adopted July 18th, 1894, by a Committee of the American Society of Mechanical Engineers, a Committee of the Master Steam and Hot Water Fitters' Association, and the Representatives of the Leading Valve and Fitting Manufacturers of the United States.

Size of Flange Pipe Size x Diam.	Size of Bolt Circle.	Number of Bolts	Size of Bolts, Pressure under 80 lbs.	Size of Bolts, Pressure 80 lbs. and over.	Flange Thickness at Hub of Iron Pipe.	Flange Thickness at Edge.	Width of Flange Face.
					Inch.		
2 x 6	4¾	4	⅝ x 2	⅝ x 2	1	7/16	2
2½ x 7	5½	4	⅝ x 2½	⅝ x 2½	1⅛	1/2	2¼
3 x 7½	6	4	⅝ x 2½	⅝ x 2½	1¼	9/16	2¼
3½ x 8½	7	4	⅝ x 2½	⅝ x 2½	1¼	9/16	2¼
4 x 9	7½	4	⅝ x 2¾	⅝ x 2¾	1⅜	9/16	2¼
4½ x 9½	7¾	8	⅝ x 3	⅝ x 3	1⅜	9/16	2⅜
5 x 10	8½	8	⅝ x 3	⅝ x 3	1½	9/16	2½
6 x 11	9½	8	⅝ x 3	⅝ x 3	1½	1	2½
7 x 12½	10⅝	8	⅝ x 3½	⅝ x 3½	1½	1½	2⅝
8 x 13½	11¾	8	⅝ x 3½	⅝ x 3½	1⅝	1⅝	2¾
9 x 15	13¼	12	⅝ x 3½	⅝ x 3½	1⅝	1⅝	3
10 x 16	14½	12	⅝ x 3⅝	⅝ x 3⅝	2	1 3/16	3
12 x 19	17	12	⅝ x 3⅝	⅝ x 3⅝	2	1½	3½
14 x 21	18¾	12	⅞ x 4½	1 x 4½	2	1⅝	3½
15 x 22½	20	16	⅞ x 4½	1 x 4½	2	1⅝	3⅝
16 x 23½	21½	16	⅞ x 4½	1 x 4½	2¼	1 7/16	3⅝
18 x 25	22¾	19	1 x 4½	1⅛ x 4½		1 9/16	3½
20 x 27½	25	19	1 x 5	1⅛ x 4½		1 11/16	3¾

Do not drill holes on centerline but symmetrically, each side.

Gravity System of Hot Water Heating.

The general method of conveying hot water through pipes for warming purposes, depends entirely upon gravitation for the movement of the water, while there are other systems of hot water heating in which mechanical means are used to force circulation through the pipe systems. We will first consider the gravity system of hot water circulation, and speak about other systems later on.

There are certain simple laws which govern the movement of hot water through pipes in heating systems, which must be understood in a thorough manner in order to produce successful heating plants. In hot water heating plants all pipes and radiators are filled with water, and when cold, the water stands practically without motion. The water conducts the heat from the boiler and delivers it to the various rooms through the radiators therein, therefore, the water must be set in motion in order to carry out its mission, and as there is practically no loss of water in such systems, the water in the apparatus is a mere agent or carrier of heat. Therefore, the most important points to understand in such matters is how to set the water in motion and keep it moving with the greatest velocity through the entire system without any mechanical means of forcing circulation. I take the most simple means possible to make these important points clear, so that I avoid all complicated explanations and technical terms.

When we consider the qualities possessed by water, it would appear that it was intended to be used for heating purposes from the very beginning of the world. There are two special qualities in water which make it a practical medium for the conveying of heat; first, its great density, and second, its high expansive quality, and motion is due to these two qualities by the application of heat.

Water expands 4 per cent. of its bulk in a rise of 172 degrees F. A cubic foot of water at a temperature of 40° weighs $62\frac{1}{2}$ pounds, and a cubic foot of water at a temperature of 212°, or the boiling point, weighs 60 pounds, it will be therefore seen that a loss in weight of $2\frac{1}{2}$ pounds in $62\frac{1}{2}$ pounds would be 4 per cent. or $\frac{1}{25}$th its bulk. To make this more clear we will make use of the illustration, Fig. 219, which represents two tubes of the same diameter and the same length, 26 feet, the tube on the left has water in it to a height of 25 feet, and this water has a temperature of 40°, as marked below it, while the tube on

the right is filled with water, but at a temperature of 212°, so that if we have twenty-five gallons of water in a system of pipes for heating purposes, there must be provision made for twenty-six gallons, where temperatures are not carried above the boiling point, and the same proportion of allowance for expansion to any temperature. As water is practically incompressible there must in all cases be provision made to take care of the expanded water, otherwise the enormous pressure produced in the system by the expansion of the water would burst some part of the apparatus.

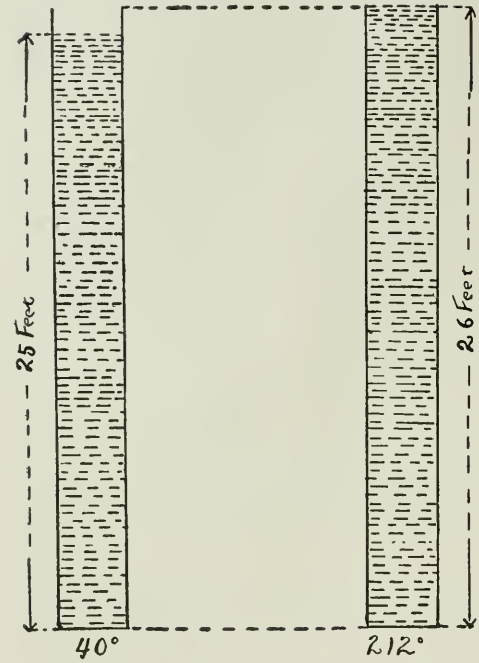


FIG. 219.

Referring to the illustration, Fig. 219, we will now consider what the expansion of the water has to do with circulation, and as will be remembered the two tubes each contain the same weight of water, but at different temperatures. We now connect the two tubes together at their lower ends, as shown in Fig. 220, each tube having the same weight of water and temperature as before they were connected, and yet the water in each tube will stand at different heights as before, and without motion. This is sufficient proof that water will rise above its source of supply by the application of heat, and also shows the amount of motive power that can be obtained for gravity circulation of water.

This uneven temperature in the two columns of water also changes the hydrostatic pressure, because it has changed the specific weights of the two waters. We can therefore tell what power we have for producing circulation

by knowing the difference in temperature between the water in the rising or flow main in a hot water heating system, and that which moves in the return pipe to the heater. With the great difference in temperature of 172° as mentioned above in illustrations, we find there is a head of water to move circulation of 12 inches in 25 feet of vertical height, which means less than a half pound pressure per square inch, but this great difference of temperature between the flow and return waters is not possible in practise, so that when we have

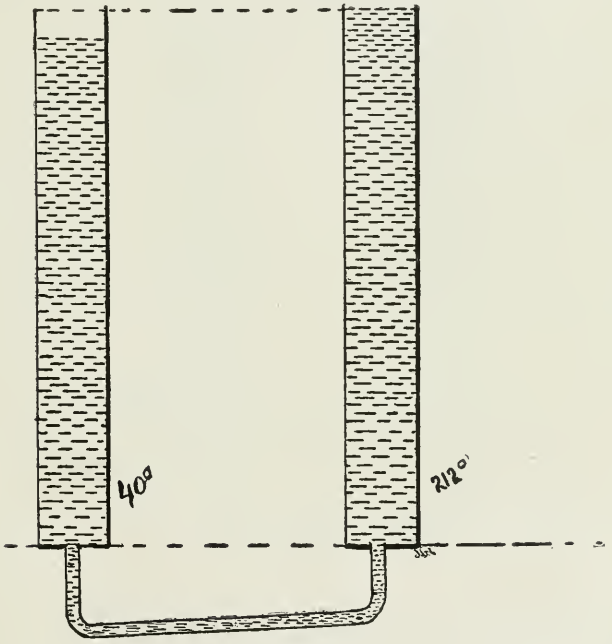


FIG. 220.

only a difference of ten or twenty degrees between the flow and return waters it will be seen that the motive power will be very little, and therefore it becomes necessary to so construct the pipe system in a manner giving the least possible resistance to the flow of water.

Whatever percentage of temperature the flow water in a hot water heating

apparatus may have above that in its return pipes, the hydrostatic pressure of the hot column will have lost the same percentage of power.

Mercury will sustain a column of water more than thirteen times its own height, and this is due to its greater specific weight. Therefore when we change the temperature of a part of the water in a heating system we will have, practically speaking, two kinds of liquid in the system.

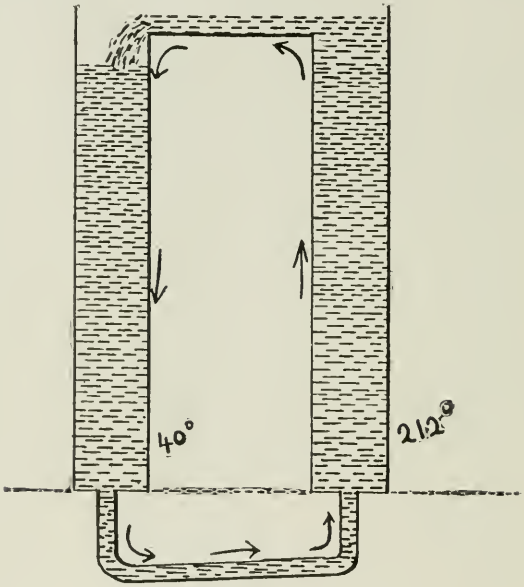


FIG. 221.

Referring to illustration, Fig. 221, it will be noticed that the tubes are connected at both upper and lower ends, and having the water of the same temperatures as marked, one at 40° and the other at 212°, the water standing in the highest leg must, by gravitation, flow over into the tube having a less height of water, which changes the equilibrium by adding more weight to the cold water leg. And, therefore, by means of this unequal pressure, the water is forced to circulate through the apparatus, and it will continue to do so as long as the water in the returns has a lower temperature than that in the

boiler and flow pipes, and as one is continually receiving heat while the other is as constantly parting with it an equality of temperature never can occur; if it did the circulation would cease. So we find the circulation of water in an apparatus is caused by the unequal pressure in the "up" and "down" pipes, and is not the result of any alteration in the level of the water contained.

A greater permanence of temperature may be obtained by hot water than by any other method, and it is also superior in its economy of fuel.

The relative weight of steam and water at 212°, are about as 1 is to 1,640. So that a pipe filled with water at 212° contains 1,640 times the matter that it does when filled with steam. When the temperature of the steam falls below 212° condensation begins and continues until all its latent heat is abstracted, it then contains a heating power of an equal bulk of water or as quantity occupying $\frac{1}{1640}$ part of space the steam did. The specific heat of steam as compared to that of water is for equal weights as .847 is to 1, and taking the latent heat of steam at 1,000° the relative heat from equal weights of condensed steam and water by reducing their temperatures from 212° to 60° is as 7.425 is to 1, but for equal bulks it will be as 1 for steam to 228 for water; therefore, steam will lose as much heat in 1 minute as the same bulk of water will lose in $3\frac{3}{4}$ hours.

The colder the water in the descending pipes as compared with that in the boiler, the more rapid will be the circulation through the pipes.

The gravitating force of an apparatus is inversely proportioned to the temperature; that is, it is less as the temperature is greater.

Provision must be made for the escape of air in the pipes, else no circulation can be had. Water while boiling evolves air, and when cooling it imbibes it again; and as air is lighter than water, it lodges in the high parts of the circulating pipes, and allowance must be made for its escape or for carrying it off.

With closed boilers, pipes may be carried to any height, depending only on the strength of the material employed. The higher the ascending and descending pipes are run, the more rapid will be the motion of the water, because of the greater difference in their weights.

The pressure by water is calculated by its columnar height reckoned from the bottom of the vessel, and this pressure on each square inch of surface increases at the rate of about $\frac{1}{2}$-pound for every foot of perpendicular height.

To increase activity of circulation.—There are two ways of increasing the

effective or motive power, viz., by causing water to cool a greater number of degrees by transit through greater length of pipe or by exposing it to more surface in proportion to water contained in pipes, and second, by increasing the vertical height; this last is principally depended upon when additional power is required to overcome obstructions.

If the circulation be doubled in velocity, the water will pass through the same length in half the time and lose only one-half as much heat, because the rate of cooling is not proportioned to the distance through which water circulates, but to the time of transit.

Increased velocity is indicative of increased power, and in hot water apparatus it is increased velocity which overcomes unusual obstructions.

Care must be taken in arranging pipes so that water in its descent may not be obstructed by differences of level or angles where air may accumulate, for this effectually prevents circulation by dividing the streams.

Since difference in the temperatures of the two columns is essential, the water should rise as much as possible directly it leaves the boiler while it is hottest and lightest, and do most of its falling just before entering the boiler, when coldest and heaviest; and as the motive power at best is small, every advantage should be taken of it. Flow pipes should be covered to retain heat to point where they are to be used. With the return pipe it is not important, as any loss of heat is compensated for by increased circulation.

The advantage of conveying the water through ascending pipes from boilers is twofold. It allows the freest escape for the air and steam, which prevent circulation, and also facilitates the circulation by increasing the actual and relative weight of the descending column.

To Calculate Velocity of Flow.—Thus, with a height of ascending pipe equal to 10′ and a difference in temperatures of the flow and return pipes of 8°, the difference in their specific gravities will equal 81.6 grains or $\div$ 7000 = .01166 lbs., or $\times$ 2.31 (feet of water in one pound) = .0269 feet, and by the law of falling bodies the velocity will be equal to $8\sqrt{.0269} = 1.312$ feet per second or $\times$ 60 = 78.7 feet per minute. In this calculation the effect of friction is entirely omitted. Considerable deduction must be made on this account. Even in apparatus where length of pipe is not great, and with pipes of larger areas and with few bends or angles, a large deduction for friction must be made from the theoretical velocity, while in large and complex apparatus with small head, the velocity is so much reduced by friction that

sometimes as much as from 50 to 80 per cent. must be deducted to obtain the true rate of circulation.

Velocity Modified by Areas of Pipe.—The motive power of the circulation increases with the size of pipe; that is 4″ being 4 times that in 2″, or about as their areas, but resistance also increases in the same ratio, so that the actual working effect is the same in pipes of all sizes.

WATER BETWEEN 32° AND 212° F.

Temperature, Fahr.	Heat Units per lb.	Weight, lb. per cub. ft.	Temperature, Fahr.	Heat Units per lb.	Weight, lb. per cub. ft.	Temperature, Fahr.	Heat Units per lb.	Weight, lb. per cub. ft.
32°	0.00	62.42	123	91.09	61.68	168	136.45	60.81
35	3.02	62.42	124	92.10	61.67	169	137.46	60.79
40	8.06	62.42	125	93.10	61.65	170	138.46	60.77
45	13.08	62.42	126	94.11	61.63	171	139.47	60.75
50	18.10	62.41	127	95.12	61.61	172	140.48	60.73
52	20.11	62.40	128	96.13	61.60	173	141.49	60.70
54	22.11	62.40	129	97.14	61.58	174	142.50	60.68
56	24.11	62.39	130	98.14	61.56	175	143.50	60.66
58	26.12	62.38	131	99.15	61.54	176	144.51	60.64
60	28.12	62.37	132	100.16	61.52	177	145.52	60.62
62	30.12	62.36	133	101.17	61.51	178	146.53	60.59
64	32.12	62.35	134	102.18	61.49	179	147.54	60 57
66	34.12	62.34	135	103.18	61.47	180	148.54	60.55
68	36.12	62.33	136	104.19	61.45	181	149.55	60.53
70	38.11	62.31	137	105.20	61.43	182	150.56	60.50
72	40.11	62.30	138	106.21	61.41	183	151.57	60.48
74	42.11	62.28	139	107.22	61.39	184	152.58	60.46
76	44.11	62.27	140	108.22	61.37	185	153.58	60.44
78	46.10	62.25	141	109.23	61.36	186	154.59	60.41
80	48.09	62.23	142	110.24	61.34	187	155.60	60.39
82	50.08	62.21	143	111.25	61.32	188	156.61	60.37
84	52.07	62.19	144	112.26	61.30	189	157.62	60.34
86	54.06	62.17	145	113.26	61.28	190	158.62	60.32
88	56.05	62.15	146	114.27	61.26	191	159.63	60.29
90	58.04	62.13	147	115.28	61.24	192	160.63	60.27
92	60.03	62.11	148	116.29	61.22	193	161.64	60.25
94	62.02	62.09	149	117.30	61.20	194	162.65	60.22
96	64.01	62.07	150	118.30	61.18	195	163.66	60.20
98	66.01	62.05	151	119.31	61.16	196	164.66	60.17
100	68.01	62.02	152	120 32	61.14	197	165.67	60.15
102	70.00	62.00	153	121.33	61.12	198	166.68	60.12
104	72.00	61.97	154	122.34	61.10	199	167.69	60.10
106	74.00	61.95	155	123.34	61.08	200	168.70	60.07
108	76.00	61.92	156	124.35	61.06	201	169.70	60.05
110	78.00	61.89	157	125.36	61.04	202	170.71	60.02
112	80.00	61.86	158	126.37	61.02	203	171.72	60.00
113	81.01	61.84	159	127.38	61.00	204	172.73	59.97
114	82.02	61.83	160	128.38	60.98	205	173.74	59.95
115	83.02	61.82	161	129.39	60.96	206	174.74	59.92
116	84.03	61.80	162	130.40	60.94	207	175.75	59.89
117	85.04	61.78	163	131.41	60.92	208	176.76	59.87
118	86.05	61.77	164	132.42	60.90	209	177.77	59.84
119	87.06	61.75	165	133.42	60.87	210	178.78	59.82
120	88.06	61.74	166	134.43	60.85	211	179.78	59.79
121	89.07	61.72	167	135.44	60.83	212	180.79	59.76
122	90.08	61.70						

Friction of water in pipes varies according to their arrangement and size, being much greater in small than in large pipes, because of greater surface the water contained is in contact with and its increased circulation on account of its more rapid cooling. By increasing velocity the friction is increased nearly as the square of the velocity.

Water loses less of its heat in small than in large pipes, since it travels more rapidly, and the loss of heat by water is directly as the time and the surface conjointly.

Water has a greater specific heat, or heat absorbing capacity, than any other known substance (bromide and hydrogine excepted), and is the unit of comparison employed for all measurements of the capacities for heat of all substances whatever. The specific heat of water is not constant, but rises in an increasing ratio with the temperature, so that in requires slightly more heat the higher the temperature, to raise a given quantity of water from one temperature to another. The specific heat of ice and steam are, respectively, .504 and .475, or practically about half that of water.

Construction of the Hot Water Plant.

From what has been said on hot water as a medium for heating buildings, it will be seen that the most important thing is to so construct the apparatus that there will be the least possible friction to the flow of water through the pipes. And in order to properly carry out this intention, special hot water fittings must be used, which are specially constructed for this purpose having long graceful curves as shown in illustration, Fig. 222.

The common or ordinary size steam or water fittings are too short in their angles, and therefore add very much friction to the flow of water. THE PROPERLY CONSTRUCTED HOT WATER FITTING is shown in section in illustration, Fig. 223.

In this fitting, as will be noticed, the inside area is the same as the inside area of the pipes to which it is connected, so that with the ends of the pipes cut off square as shown in the fitting, there will be no obstruction to the flow of water as it leaves the fitting, and besides with such fittings it would not be necessary to ream out the ends of the pipe.

The arrows in the cut will give us some idea of the waters direction as it leaves and enters the ends of the pipe in passing through the fitting.

In this case there would only be the friction due to the shortness of the bend to contend with, there would be no conflicting currents, nor eddies formed, for the reason that in this make of fitting there is no projected surface to cause them.

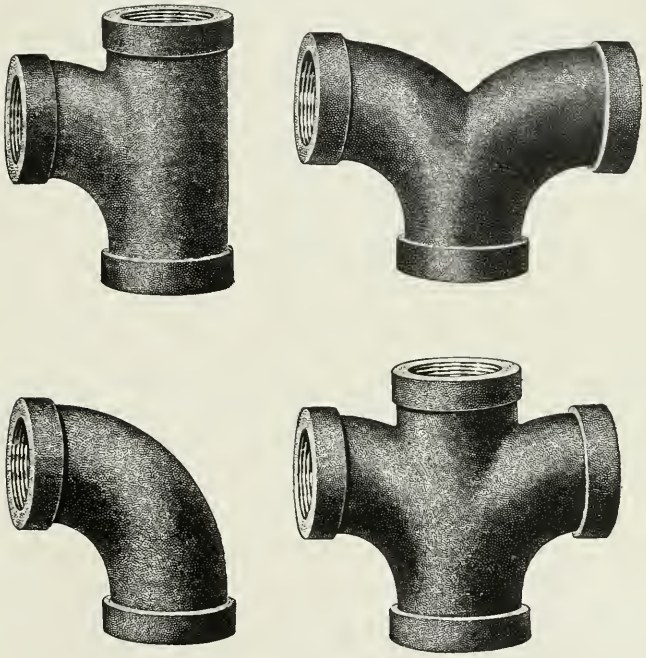


Fig. 222.

In this fitting it will be noticed that the ends of the pipe do not butt up close against the inner shoulders of the elbow, leaving a little recess, and in this recess there is no thread, the thread in the fitting running in only as far as the end of the pipe as shown. The reason of this is to make it possible to screw up the pipe tight depending entirely on the threads and not on the ends of the pipe butting up against a shoulder.

In such a case as shown if the joints could not be made perfectly tight before the pipe extended in to the fitting as far as the shoulder, it could never

be made tight, for the reason that the shoulder would be an obstruction, and unless both the inner shoulders of the fittings and the ends of the pipes were ground in the order of the ground joint coupling they would leak. Therefore taking the several points into consideration, making the body less in diameter,

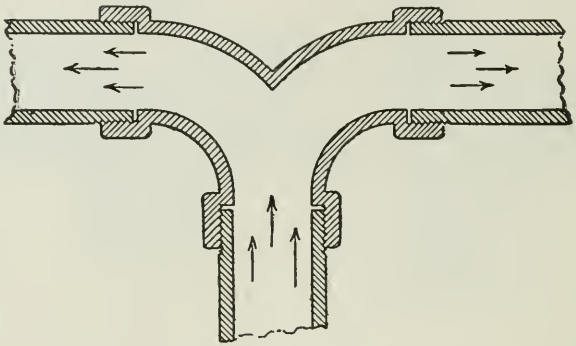


Fig. 223.

cutting out, as it were, the end obstructions, and making it practical to tap easily and also making it unnecessary to ream out the ends of the pipe the fitting shown in Fig. 223 would be a great improvement with many points in its favor for hot water heating plants.

How Ends of Pipes Should be Reamed.

If the ordinary style fittings are used on hot water circulating systems, such as are not recessed, all ends of pipes should be carefully reamed out in a manner as shown in illustration, Fig. 224, and unless the ends of pipes are

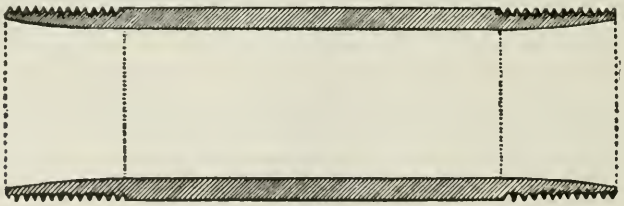


Fig. 224.

reamed taking off at least the burr, there will not only be a large amount of friction due to such obstructions, but the capacity of the pipe will be greatly

reduced by the burrs contracting the area of the pipes at each end, and while the average fitter might consider this a small matter and in a measure a waste of time to ream the ends of pipes, he is working against his own interests if he desires to construct a good, easy, and economical working heating plant. It more than pays, in fact it is a good investment to carefully construct the pipe work of a hot water heating plant and avoid as much as possible any cause of friction to the movement of the water.

Rapid Circulation of Hot Water.

It must be remembered that the more rapid the circulation may be through the pipe system of a heating apparatus, the more heat will be given off through the radiating surface, and consequently the sluggish apparatus will require more radiating surface to do the same work of one having a good circulation, and this is where it will pay the heating engineer to use every effort in producing the best circulation possible. The quick circulating plant is also the most economical in the consumption of fuel, and therefore the consumer gets a better bargain the better the circulation. All these points should be taken into consideration throughout the complete heating apparatus. The style of radiation used must be considered not only as to its surface but as to its construction regarding the circulation of water through it.

Some makes or styles of radiators may be good for steam heating, but might not answer at all for hot water heating, while on the other hand a good hot water radiator is always a good radiator for steam heating. For the matter of illustration as to the friction in bends over that in straight lines of pipe, we make use of sketch, Fig. 225, which was used by the writer in a series of articles for the American Artisan, with the following description.

As stated in other parts of this book, the cause of circulation in a hot water heating apparatus is the difference in weight of the water in the flow pipe and that in the return. And even with the greatest difference in temperature of these two columns of water that can be had in general house heating, the motive power will be very little, and consequently it is quite necessary to carry all hot water pipes in as favorable a manner as possible, avoiding all dips and air pockets, also short bends. A simple manner of illustrating friction in the flow of water through pipes at various angles is shown in the accompanying illustration, which represents five railway tracks. For a matter of comparison, let us suppose that a locomotive is placed on each track in a line, the tracks all

being of the same distance, but of different angles, and the locomotives all starting at the same time under the same conditions, it would not be necessary to ask the question which locomotive would reach the end of its track first. By referring to the illustration the arrows indicate where situate close to the outside rail on the different tracks, the points of friction with which the outside wheels would have to contend with, Track one is perfectly straight and, therefore, has nothing to retard the motion of the wheel, as indicated by the arrows all in the center. Track two has a small curve which would very much

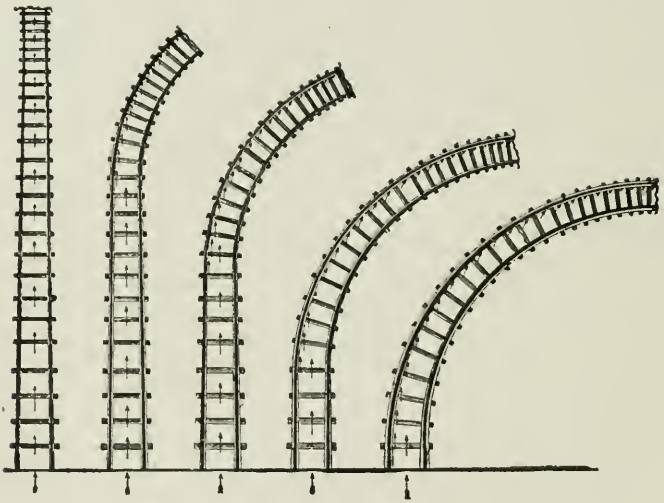


FIG. 225.

retard the motion, while tracks three, four and five have still greater curves. By referring to track five it will be noticed that in this case there will be friction from the very starting point to the finish, and this might represent an elbow in a hot water heating plant. Short elbows and bends, therefore, for such work are great obstacles to the rapid movement of water in any heating apparatus. Long bends should be used where angles are necessary, in branches

as well as elbows. It requires energy to produce friction, and energy is power; therefore, the energy and power used by friction in the pipes of a hot water heating apparatus require a certain percentage of the fuel consumed in the heater; this is a total loss, for the reason that from this percentage of fuel no heat is derived. Many fitters are under the impression that whatever will conduct steam in a steam heating apparatus will also answer just as well for the conveying of hot water in a hot water heating apparatus, forgetting that steam and water are two widely different things. It must be remembered that when we have water flowing through a pipe we are dealing practically with a solid matter, compared to that of steam. There is practically no compressibility to water, and when in motion passing through pipes and bends, it produces friction to a much greater extent than steam or other gases, which have great flexibility. What do we gain with rapid circulation in a hot water heating apparatus? In the first place it is necessary to have the water circulate from the boiler to the radiators in order to convey the heat to the various rooms of the building. After the hot water has given off a portion of its heat to the radiators, its temperature will have lowered to a point where it is of no further use for imparting heat to the radiating surface. The particles of water after losing part of their heat, being no longer of value, must hurry back to the boiler, or source of heat for a new supply, which in due course is again imparted to the radiating surface. Rapid circulation in a hot water heating apparatus benefits the boiler when considered from the standpoint of economy in fuel. Both the duty and action of the boiler in a heating plant are just the opposite to that of the radiation surface, and in order to get the most work from the boiler with the least amount of fuel, the return water must flow into the boiler as quickly as possible in order to take up as many as possible of the heat units produced by the fuel consumed in the boiler, and allow as little of heat to pass to the chimney unutilized. The more rapid the circulation of the water through the boiler the greater efficiency will be attained in the entire heating apparatus.

Coils for Hot Water Heating.

When pipe coils are used as radiating surface, they should be constructed as near as practical to those shown in the following illustrations of hot water heating coils.

The coil shown in Fig. 226 is fed through a beader or manifold on the expansion end, and all return water discharges into a vertical manifold on the return end and from this drops vertically to the cellar or lower floors, and this is the best method to carry out in long or short coils, because the water will only have to travel once the length of the coil in the coil, and it is also good policy to keep such coils as short as possible for good effective work.

It is often necessary, due to location turn end or other circumstances, to bring back the return pipe from a coil at a point

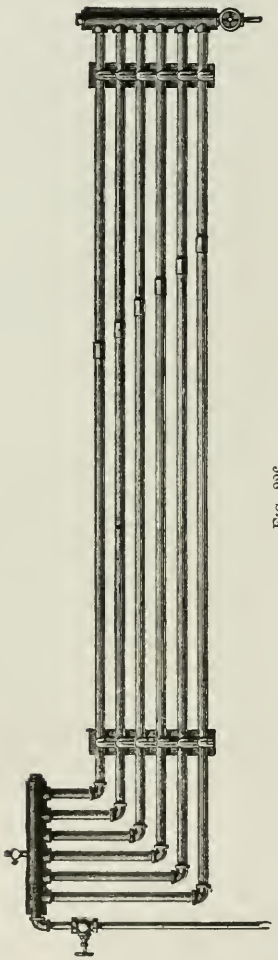


Fig. 226.

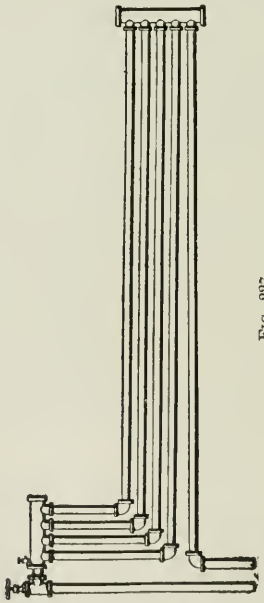


Fig. 227.

near the riser as shown in Fig. 227, and which may be done, but the circulation

through this coil will not be so rapid, because the lower pipe must carry all water from the balance of the coil.

How Long Coils Should be Constructed.

Where it is necessary to use long heating coils, and this means for steam as well as for hot water, unless laid out properly the return end of coil will not give the amount of heat that will radiate from the supply end of same, although there may be the same amount of surface, and therefore the room to be heated

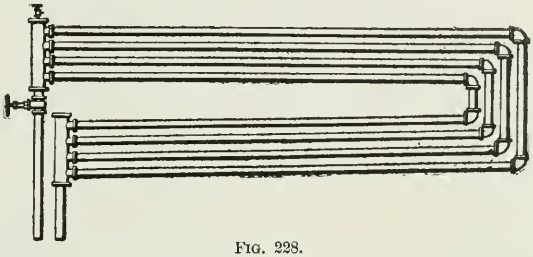


Fig. 228.

at the return end of a long coil, if constructed as shown in Fig. 226, will suffer, and to overcome this, long coils may be constructed as shown in Fig. 228, having the pipes divided in two parts, each with a manifold at the same end, one for the flow of water, and the other to receive the return water, so that the temperature of water throughout the coil will be at a more average heat. The

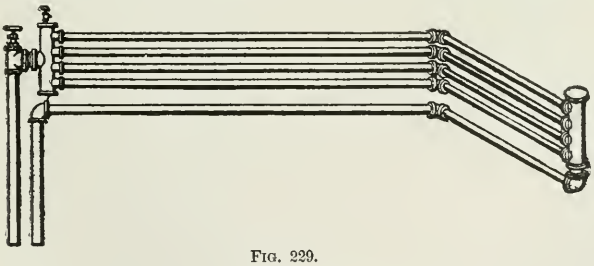


Fig. 229.

upper pipes will be warmest at the end nearest the flow manifold, but the return part of the coil directly under same will be the coldest, and therefore an equalization of the temperature in the coil is obtained at all points along the line.

By the method of connecting the flow line to coil as shown in illustration, Fig. 229, the valve which controls the supply can be placed in a more convenient position for operating same, and at the same time should this end be a corner or close to a wall it would save room by connecting as shown to back of manifold. As will be noticed by referring to all hot water coils supplied from below, air valves are placed at the highest points, so that all air can be taken from the coils.

Single Pipe Return Coils.

When hot water coils are constructed of the single return bend pattern as shown in Fig. 230, they should never be longer than four to six feet, and not have more than four to six pipes in height, because this is simply a single pipe, and a coil of this made 6 feet long and 6 pipes high would contain 36 lineal feet of pipe, it will therefore be seen the return or lower section cannot have much heat even in a small coil of dimensions given.

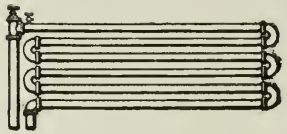


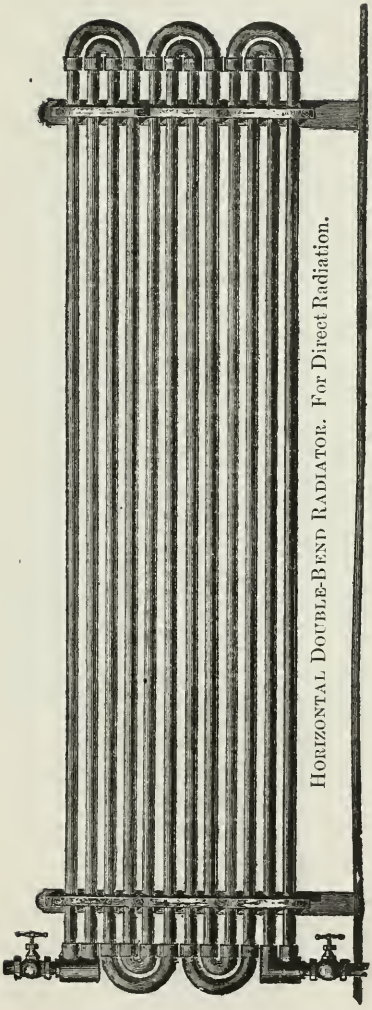
Fig. 230.

Another point in coils of this make which should be noticed, is that it will take only a small amount of air to stop circulation of the entire coil, for the reason that the upper pipe in the coil is the only space for air, so that it may be expected that without an automatic hot water air valve on such a coil, the circulation of water is partly choked off at all times by some air in this upper pipe.

The Double Return Bend Coil.

By the use of the double return bend coil as shown in Fig. 231, expansion and contraction is properly provided for, the heat is evenly distributed at each end of the coil, and the water travels only half the distance as that in the same length single pipe coil, and appearance is in favor of the double return bend coil.

A special point which I desire to bring to the notice of the fitter in constructing coils as shown in Fig. 231, is to have the lines of pipe perfectly level and properly supported so that they cannot sag at any point; it is also a good plan not to construct such coils of pipe less than 1¼ inch in diameter for hot water heating. In illustration, Fig. 232, we show the method of connecting a hot water coil from an overhead supply system, and as will be noticed



Horizontal Double-Bend Radiator. For Direct Radiation.

Fig. 231.

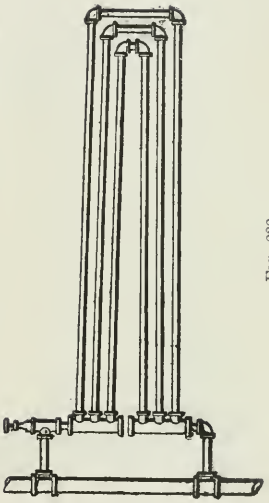


Fig. 232.

this requires no air valve and is simply provided with a controlling valve at inlet on top as shown. The supply line which drops from overhead continues down and into which the return water is carried from bottom of coil in the form of a loop.

The Lawler Method of Increasing Circulation.

If we can create a rapid circulation of the water in an apparatus without carrying a high temperature of water, we will produce the best of results, for one special reason, that the products of combustion will not leave the boiler at as high a temperature; and therefore, there will not be as many heat units wasted through the chimney. Keep the boiler busy taking care of the return water, and there will be little loss of fuel from a well constructed boiler.

The improved hot water heating apparatus shown in the accompanying illustration was designed by the writer, with the object of accomplishing the desired results as mentioned above. The special difference in this arrangement of heating apparatus to that of hot water systems is in the use of a condensing chamber in connection with the heating boiler, as shown in section on the right of the boiler in Fig. 233.

The general operation of this condensing chamber is similar to that of an indirect stack of radiation, having a special inlet at the bottom of the fresh air, as shown below the floor level and extending to a cellar window or opening above the surface of the ground. The warm air passing from the condenser is conveyed to some portion of the building to be heated through warm air ducts, as shown by the direction of the arrows.

The arrangement of this indirect heating chamber differs also from other systems in the matter of its water supply, which is fed only by return water. By the method as shown in the accompanying illustration, ventilation is provided for in introducing fresh air, and having it tempered before entering the living rooms. Every unit of heat which the return water contains after leaving the radiators above that of the temperature of the outside atmosphere, may be extracted and conveyed to the rooms through the agency of fresh air. Therefore, the greatest possible difference of specific gravity between the flow water leaving the boiler and that of the return water entering the boiler is obtained.

The results as mentioned above also result in obtaining two other points of economy and advantage, which are: First, more than doubling the velocity of the water through the apparatus; and secondly, extracting a larger number

of heat units from the fuel consumed in the boiler. There are other advantages —pipes of smaller sizes may be used, on account of the more rapid movement of the water; this is a good point, because the large size of hot water pipes connected with a heating apparatus has always been an objection, not alone on account of their extra cost over that of pipes used in a steam apparatus, but because of their appearance as well as the space which they occupy.

With a hot water apparatus arranged as shown, special points of safety are also embodied which cannot exist in other systems. There will be less

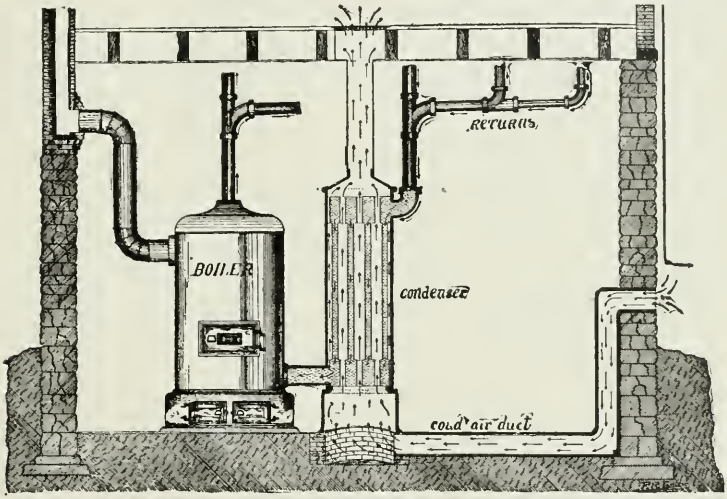


FIG. 233.

possibility of overheating the boiler, for the reason that a better circulation is always possible with a good supply of cold water entering the boiler at all times.

The arrangement shown may be likened to that of a steam condenser connected with a steam engine, which has for its object the relieving of back pressure on the piston of the cylinder at the time of exhausting, and has the effect of producing a partial vacuum in the exhaust pipe, which at times not only takes away any pressure due to friction, but assists the live steam in moving the piston by taking away the atmospheric pressure in front of it. In the

steam condenser, a jet or a number of jets of cold water are used to condense the steam. While in the case of the hot water condenser, a stream of cold air is used to condense the water and give it a greater specific weight and thereby forcing the water having a higher temperature from the boiler with greater rapidity.

In condensers used in connection with steam engines, the water which acts as the cooling agent takes up the heat lost by condensation, but this heat is utilized again by being pumped back to the boiler unless in very large plants when some of the heated condensation is allowed to waste. With the hot water condensing apparatus the cooling agent, which is fresh air, and which takes up the heat units lost by the return water, conveys the heat to places where it is fully utilized at all times. All things connected with the condensing system of hot water heating work in harmony with each other ; by the construction as shown the ventilating is improved, on the same principle as that which is the cause of the water moving with greater velocity.

The condensing chamber being placed at a low point in the building to be heated, which is the most convenient place of location in order to take in all return water from the radiation, at the top of the condenser, rarifies the cold air at the bottom entrance, and the higher the fresh air rises the hotter the surface will be with which it comes in contact, thus increasing the difference in specific weight between the inlet supply of air at the bottom of the condenser and that which leaves it at the top.

In the construction of the hot water condenser, it may be of any desired shape, having top and bottom connections the same as any style hot water radiator, and sufficient space through which the fresh air may pass. A circular hot water radiator of either wrought iron tubular pattern or the cast iron sectional make, fitted with a sheet iron casing, would answer very well in some cases, but a specially constructed arrangement with large openings at both top and bottom would be the best. The receiving drum on top could be fitted with a number of outlets, to which the various returns could be connected separately, and the bottom of condenser could be provided with two outlets and located directly in the rear of the boiler so that the return water could enter the boiler at both sides near the bottom, which would improve the circulation in the boiler by equalizing the inflow of return water.*

* The Author in the Plumbers' Trade Journal.

How to take Branches from Mains on the Two Pipe System of Hot Water Heating.

By carrying out the system of pipe connections as shown in Fig. 234 it will be possible to keep the flow and return pipes in parallel lines with each each other and also at the same grade or elevation. In the method shown, branch pipes can cross each other from either side and still be kept in line, it is also easy to get any desired elevation to the branch lines by simply swinging the fittings connecting with the main lines to the desired degree of elevation.

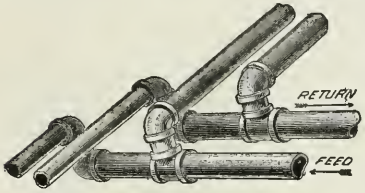


Fig. 234.

Fig. 235 show the same method of branching from main cellar lines, and the space between the main lines, as well as the distance between the branch lines should be enough to allow of each pipe to be covered with non-conducting covering, and also for the purpose of being able to turn fittings on one pipe without having to disturb the other line. Therefore this space between the lines should not be less than three inches in the clear. 45° elbows are sometimes used on the close nipples connecting to main lines and with which the branches are connected, which gives a greater elevation to the branch lines without having to throw the tees in main line out of a vertical position.

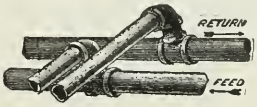


Fig. 235.

How Branches Should be Made on Hot Water Risers.

As hot water has a tendency to flow to the highest point in the vessel which contains it, care must be exercised in taking branches from hot water risers so that the hot water will also flow to radiators situated at low elevations. And therefore it is proper to take out branches on such lines in a manner as that shown in illustration, Fig. 236, so that all flow water passing to radiators on each succeeding floor above the first floor, will be taken from the side of the rising line as shown in Fig. 236, and as will be noticed the flow water which is hottest will find its way to the upper part of the branch tee,

Fig. 236.

and then pass to the low radiator, while if the branch was taken from the riser direct through the tee to radiator on the first or any other floor where there is radiation at a higher elevation, the hot water would pass the tee and flow to the highest radiator where the best kind of circulation would be produced, while the radiator thus connected at a lower level would stand practically without circulation.

The Same Flow Level.

Where it is necessary to take off two branches for two radiators on the same floor, but where the radiators are of different sizes, it is always the best practise to favor the largest radiator with the upper connection, as shown in Fig. 237.

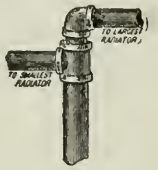


Fig. 237.

Again should the two radiators on the same floor for which two branches are taken from the riser be of the same size, it will then be good policy to favor the radiator with the upper connection which is situated in the most unfavorable position, and in this manner there will be a more even flow of hot water to each radiator on the same floor.

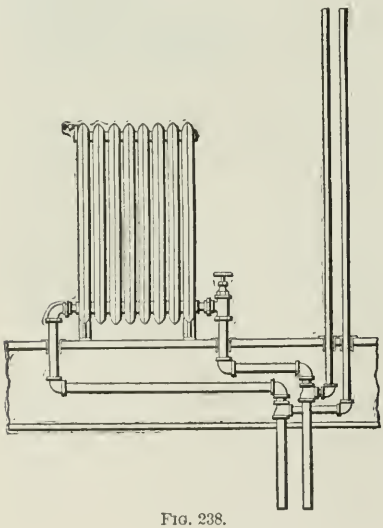


Fig. 238.

How to Make Hot Water Radiator Connections.

The system of taking out connections from risers described in Fig. 236, is carried out in illustration, Fig. 238, and this shows both the flow and return pipe connected in the same manner. By carrying out this method of connecting there is sure to be a good and even circulation on each floor. In making radiator connections direct from cellar mains, there is no better method than that shown in illustration, Fig. 239, for the reasons, as may be noticed, the branches taken from cellar mains are arranged with 45° ells which lessens the friction in the pipes over that of 90° ells

at such points, and also for the reason that the radiator is supplied at the bottom as shown.

By this method of connecting to the radiator, the circulation of the water cannot be stopped by the accumulation of a small amount of air lodging at the top of the radiator as may be done by connecting the flow to top of

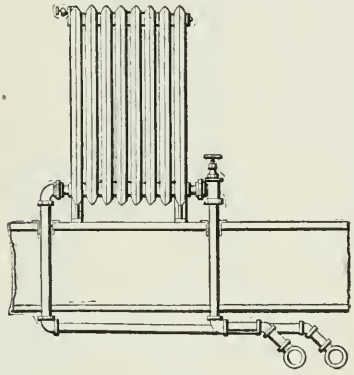


FIG. 239.

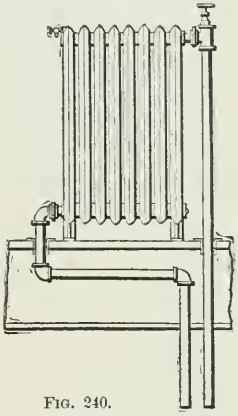


FIG. 240.

radiator as shown in Fig. 240. Where radiators are supplied from below it is the safest plan to connect flow pipes at bottom as shown in Fig. 239.

CONNECTING RADIATORS FROM OVERHEAD SYSTEMS.

Fig. 241 shows how to connect a hot water radiator to a supply line from an overhead system. As will be noticed the radiator is connected as a loop, so that the water can descend to lower radiator or back to the heater from the drop line without having to pass through the radiator, and the radiator can be used or shut off without interfering with other radiators on the same line, and this one line can be used as the return from the radiator as shown.

By this system of connecting or supplying hot water radiators, it will not be necessary to use air valves on the radiators, because all air will pass up through the supply pipes and escape at some other higher level.

In Fig. 242 we show the method of connecting radiators which are located on the same level with the boiler or heater, and in this case the supply water is carried to top of radiator from overhead supply line as shown, and the return

pipe is carried back to the boiler in a horizontal position below the floor and rising again to lower connection at boiler.

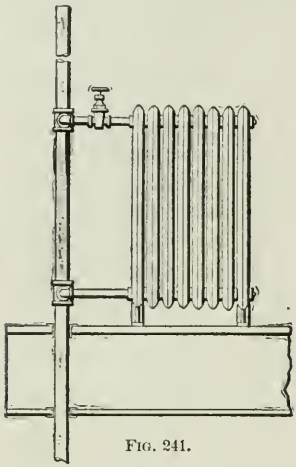


Fig. 241.

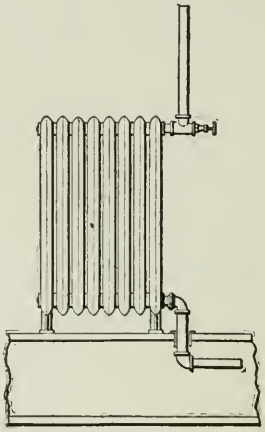


Fig. 242.

Controlling Valves for Hot Water Radiators.

Referring to the methods connecting radiators as shown in Figs. 238, 239, 240, and 241, it will be noticed that there is but one controlling valve to each radiator and this is sufficient, because all that is necessary to stop the heat to hot water radiator is to stop circulation through it, and one valve can do this as well as two. Therefore the opposite end of the radiator is usually fitted with a brass union elbow, so that both sides can be easily disconnected when desired. A well constructed controlling valve for hot water radiators differs from that of a good steam radiator valve, and it is therefore necessary to know what constitutes a good hot water radiator valve.

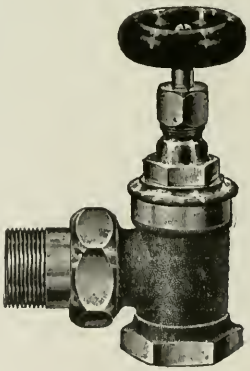


Fig. 243.

The most important feature in valves for controlling the flow of water in a hot water heating apparatus is, that they should have large and clear openings, so that there will

be as little resistance to the flow of water as possible, through them. It is not absolutely necessary that controlling valves to hot water radiators be perfectly tight, because a small leak through such valves will not produce a good circulation of the water through the radiators, or, in other words, the hot water passing into a radiator through a small leak in the valve will not heat the surface sufficient to make any great difference in the temperature of the room. Hot water radiator valves are usually constructed so that when closed off water will still flow into the radiator, just enough to keep up a slow circulation through the radiator for the purpose of preventing the water from freezing in cold places. A simple and good construction of hot water radiator valve is shown in Fig. 243. This is fitted with male union, and that shown in Fig. 244 is the same valve without union. To open this valve to its full capacity, it is only necessary to make a ¼ turn of the handle, and therefore it is sometimes called a quick opening valve. A sectional view of this same valve is shown in Fig. 245, and as will be noticed it is constructed on the plug principle, being ground to fit the sides of the body, while the inner disk or plug is hollow with an opening from bottom and one opening on side, as shown in sectional view, and the top part of ground hollow plug being closed and secured to the stem. A most important feature in any hot water radiator valve is to have it absolutely tight against any leakage of water through the stuffing box or cap. For the reason that a small leak of water from any part of a radiator or its connections can often do great damage, by wetting ceilings, carpets, and walls, while a small leak of steam from radiator connecting might do practically no damage. It will therefore be seen that without question the most important thing to consider in selecting radiator valves for hot water heating purposes is to select such as give the best security to tightness or non-leakage at the stem. By referring to the sectional illustration,

Fig. 244.

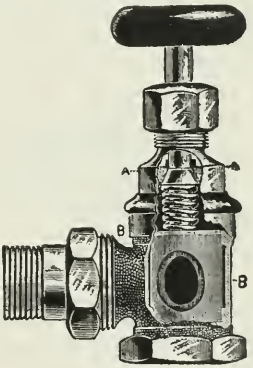


Fig. 245.

Fig. 245, it will be noticed that this special desirable feature has been considered. A spiral spring is placed above the ground plug and around the stem, which is made to act for two purposes, (first) it holds down the ground plug to its position at all times, and (second) it presses up against the stem, holding it tight to the packing in the cap or stuffing box, so that as the packing shrinks and moves away from the stem, the spring moves the ground collar of the valve stem close against the packing and keeps it there as long as the packing has any flexibility in it.

The Radiator Union Elbow.

As, stated in other places, hot water radiators require but one valve to control the heat or flow of water, and the return connection is usually made with union elbows, we therefore show in Fig. 246, a female elbow with male union, which is most generally used, and we show in Fig. 247, a male elbow with female union. In regard to which end of a hot water radiator the valve should be placed, I desire to state practically speaking, this does not matter, but it is good practise to come at the flow pipe to the nearest end of the radiator to the flow line, and at the same time place the valve on the inlet; yet there are often situations where the flow connection to a radiator, would be an inconvenient place to operate the valve, and in such places the controlling valve may be placed on the return connection as a matter of convenience for operating same.

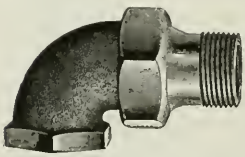


Fig. 246.

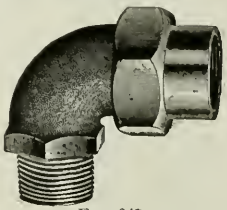


Fig. 247.

Gate Valves for Hot Water.

Gate valves are the only proper construction of valve for use on straight lines of hot water circulating work, and globe valves should not be used in any position or under any circumstances where water must circulate by gravitation alone. The gate valve gives a straight and full opening, so that there can be no air locking or trapping to prevent circulation and at the same time such construction gives but little resistance to the flow of water.

There are many modifications of the gate valve but the object in them all is to clear the straight passageway by lifting the wedge-shaped disk entirely above the opening and allow the water to flow as it does through a straight piece of pipe.

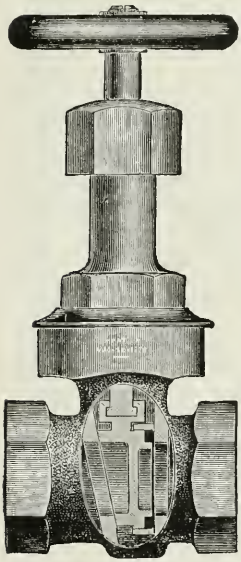


Fig. 248.

Pipe System for Hot Water Heating Plants.

We will now proceed to describe a few of the many methods of piping for hot water heating systems. Some heating engineers prefer to carry a separate supply from the boiler to each radiator or riser, and also with a separate return from each as shown in illustration, Fig. 249, and in a method of this kind there can be little question about getting a good circulation to each and every radiator, providing that each flow pipe will have same rise the entire distance from top of boiler to radiator connection, and the returns to have a fall back to bottom of boiler.

However, the separate pipe system would prove entirely too cumbersome, complicated, and expensive where large numbers of radiators are necessary, besides a good circulation of the hot water can be produced through any number of radiators fed from one main flow line; but a more thorough knowledge of the principles of circulation will be necessary in order to secure the best results.

In Fig. 250 we show a hot water heating plant, with direct radiators on each end and side of a first floor with the boiler in the basement or cellar, such as might be expected in churches or large halls, and the method of pipe work shown has been used to a great extent, but often with poor results. As will be noticed a flow pipe is taken from top of boiler to each side of building and connecting to all radiators on its line, and these flow pipes are placed with a slight rise from the boiler to the last radiator as indicated, while a corresponding pipe brings back the water from all radiators, and delivers same to bottom of boiler as shown by direction of the arrows in illustration. These pipes are properly proportioned in size to feed the entire radiation, starting at

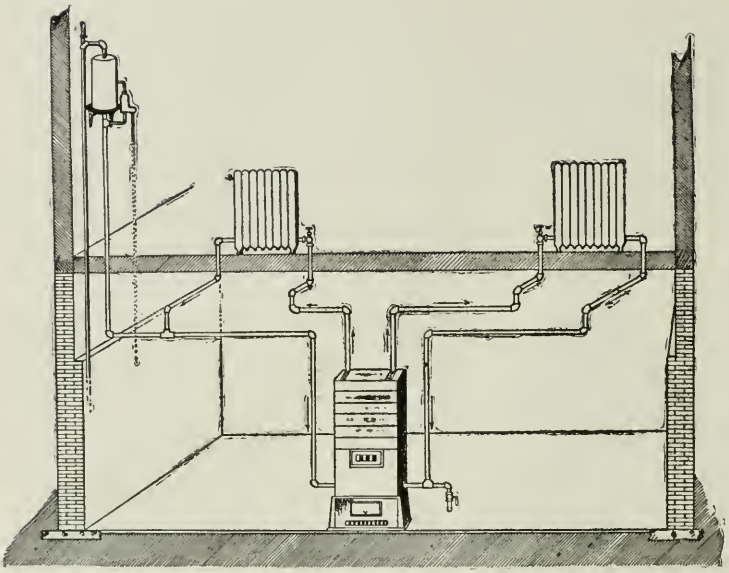


FIG. 249.

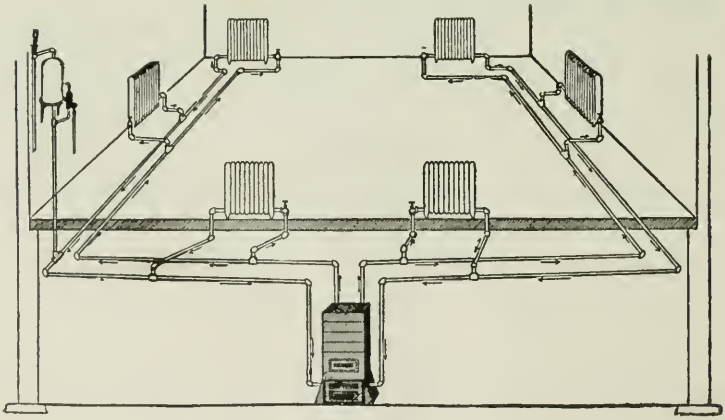


FIG. 250.

the boiler with full capacity for all radiation on each line and reducing in size as connections are taken off, so that the last connections to the most distant radiators from boiler will be the smallest size. This illustration, Fig. 250, is used for the purpose of pointing out to the mechanic where difficulties will be experienced with such methods of piping, and how to avoid trouble. In long horizontal lines of hot water pipes reduced in size as described above, there can only be a slow circulation, because, as a rule, there will not be sufficient height in such basement or cellar to allow giving much elevation to the flow lines, and the result will be that the radiators situated at the most distant points from the boiler, will be cold, or practically so, most of the time, while those nearest the boiler will have a high temperature. It will be found that in such plants, the most distant radiators will not get warm until long after all other radiators have been heated, and then at times a poor circulation will begin in them. Therefore, where plants are to be piped on the principles shown in Fig. 250, the main cellar lines should be of much larger size, and not reduced, in extending to the last radiators on the lines. The flow pipe should be covered with good non-conducting covering the entire distance from boiler to last radiator, and the most distant radiators should be supplied at top in place of bottom, which will give greater elevation to the last flow connection, and they will therefore have less cold water to contend with in starting circulation. In the illustrations, Figs. 249 and 250, it will be noticed that the expansion tank is connected to the return main; this will answer where there are no valves on the main lines that may be closed to the boiler, and also where the tank is located in a warm place. Expansion tanks will be considered separately in another place, but I desire to state here that the tank must be located above all radiation and must be provided with an overflow pipe, also an air inlet on the overflow pipe to admit air to discharge pipe and prevent siphoning of tank when it overflows.

Hot Water Radiators Unfavorably Situated.

In the course of practical experience, the fitter very often meets situations quite similar to that shown in the accompanying illustration in regard to the location of radiators. That is, with some and often the greater part of the radiation located at the highest point in the house, and at the same time quite direct over the boiler, while the other portion of it may be distributed at some distance from the boiler on the lower floor. And without making any special

provision for such conditions, the general tendency of the hot water would be to flow rapidly through the high radiators without circulating at all through those situated on the lower floor. And the special reason for this is that the

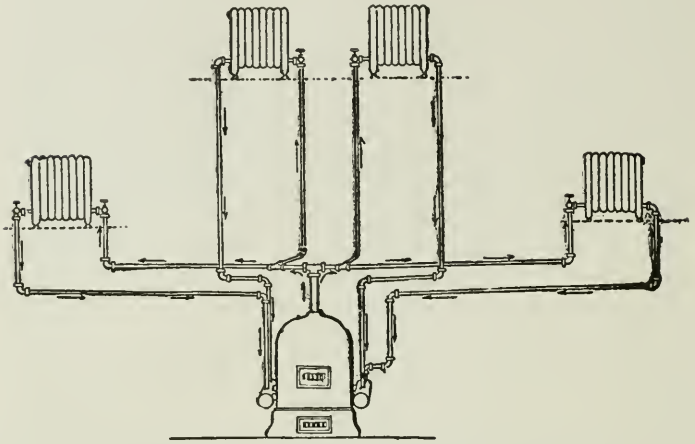


FIG. 251.

hot water returning from the radiators which are heated, first warming the water in part of the return pipes of the radiators situated on the lower floor, which causes a balance of weight in the flow and return pipes connected with the unfavorably situated radiators. In hot water plants where such trouble as mentioned above is encountered, the fault will be found in having the return pipes from the highest radiators connected with the main horizontal return lines of the lower radiators at high points near the cellar ceiling. And to overcome the trouble it will be necessary to carry each return line the entire distance to the bottom of the boiler, as shown in the accompanying illustration. In a plant of this kind, all supply connections may be taken from the same main flow line to the various radiators, if necessary, throughout the building, no matter on what floor they may be situated, as shown in the illustration. Therefore, the critical point of getting a good and satisfactory circulation of hot water through radiators situated as shown depends specially upon how the returns are run. This point just cited is very similar to running the return

pipes from steam radiators below the water line of the boiler to guard against steam flowing up the return pipes of radiators less favorably situated. Again referring to the illustration, it may be noticed how the branches are taken from the main flow line to the radiator situated on the upper floor; they are taken from the side in place of the top as in other cases by taking the water from the side of the main flow line, in such cases retards the flow in a measure to the high points, and improves the flow to radiators situated on lower floors, which has a tendency to equalize the flow of water to all points in the plant. In a hot water system as shown in the illustration, although there is but one main flow pipe, each radiator throughout the building will have an independent circuit, and in no way will the flow or return water of one conflict with that of any other.

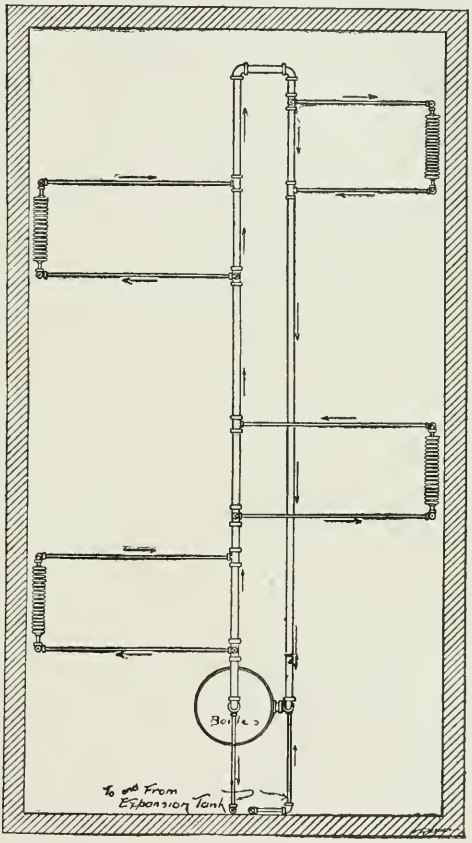


FIG. 252.

A Good Method of Hot Water Piping to Produce Equal Circulation to the Various Radiators Throughout the Heating Plant.

As I have said on other occasions, one of the most difficult problems with which the heating engineer has to contend is the equal distribution of the heated water to the various radiators. However, experience and experiments are gradually telling us how this may be successfully accomplished. A short time ago some of the best experts in the line of hot water heating considered that an equal supply of hot water to the different radiators could only be accomplished by separate flow and return pipes for each radiator, and many plants were constructed on this plan. The separate line system was open to great objections on account of the network of pipes which it necessitates, which wasted so much cellar room, besides adding so much extra joints, which always increased the possibility of leaks. And at the same time the special object sought for, namely, equal supply, was never accomplished. By practical experience and careful observations, the writer is satisfied that the less number of pipes leading to and from the boiler of a hot water heating plant, the better will be the circulation, as well as the more complete distribution of hot water to the various radiators, resulting in a more uniform temperature throughout the building. Probably the greatest difficulty experienced from sluggish circulation is in plants having long horizontal lines from the boiler, while some radiators on the same plants are situated but a few feet from the boiler. The accompanying illustration, Fig. 252, represents a hot water heating plant with the boiler located at one end of a long building, and radiators distributed at various points. In several plants of this kind recently examined by the writer, such a perfect circulation and distribution were produced in each case that from the touch no perceptible difference could be noticed between the most favorably situated radiator to the boiler and the one the greatest distance from the boiler.

Referring to the accompanying illustration, there are but four radiators shown, but it makes little difference how many there may be, provided they are all connected up in the same manner. If radiators are located on each side of the building as shown, and the building comparatively narrow, one main circuit through the center of the cellar as shown would be the best plan; this means where the lateral branches to the radiators would not be very long. Starting with the main flow pipe at the boiler, it is carried near the ceiling and

run to the extreme end of the building, or as far as the last radiator, with a gradual and slight incline down away from the boiler, returning again with the same gradual fall towards the boiler, to a point near the boiler, where it drops vertically and enters the bottom of boiler as shown on the right of boiler in the illustration. It will not be necessary to give these pipes much fall; besides, they are more out of the way near the ceiling, giving better head room, and also look much the best. Whatever the capacity of the main flow pipe at the boiler may be, this should be continued around the main circuit, connecting again at bottom of boiler the same size as the flow outlet, and not reduced at any point.

We can readily see that this is a good method for the reason that it keeps up a circulation the entire distance from the boiler in the circuit, whether radiators are in operation or not, so that each radiator will have simply its own lateral branches as its circuit; in other words, the boiler by the trunk circulation is practically located at the branch to each radiator. The direction of the arrows in the illustration shows the direction of the water as it moves through the various pipes and branches in the apparatus. As will be noticed, the supply to each radiator is taken from the main flow at top of the flow line, while the return water from the various radiators is carried back and enters the side of the same flow line as shown. Provision is made for the escape of air by carrying a small pipe from the highest point on the flow pipe to the expansion tank, with a return pipe also from the tank, so that a circulation of the hot water will be produced through the tank and its connections to keep it from freezing. In this system of piping while the radiation nearest the boiler is first supplied, and with the water at highest temperature, the return water from such radiation will be the last to get back to the boiler, therefore in this way an equalization of the temperature throughout the plant is, practically speaking, produced. In wide buildings or houses, the circuit may be carried near cellar walls, which would shorten the lateral branches, and rises to any height may be supplied in the same manner as shown in Fig. 252.

The Overhead Supply System Of Hot-Water Heating.

The illustration, Fig. 253, represents one method of pipe work for the overhead supply system, and one special feature in this is that air valves will not be required on any part of the apparatus, for the reason that all pipes are carried in a manner so that air cannot lodge at any point. The radiators are

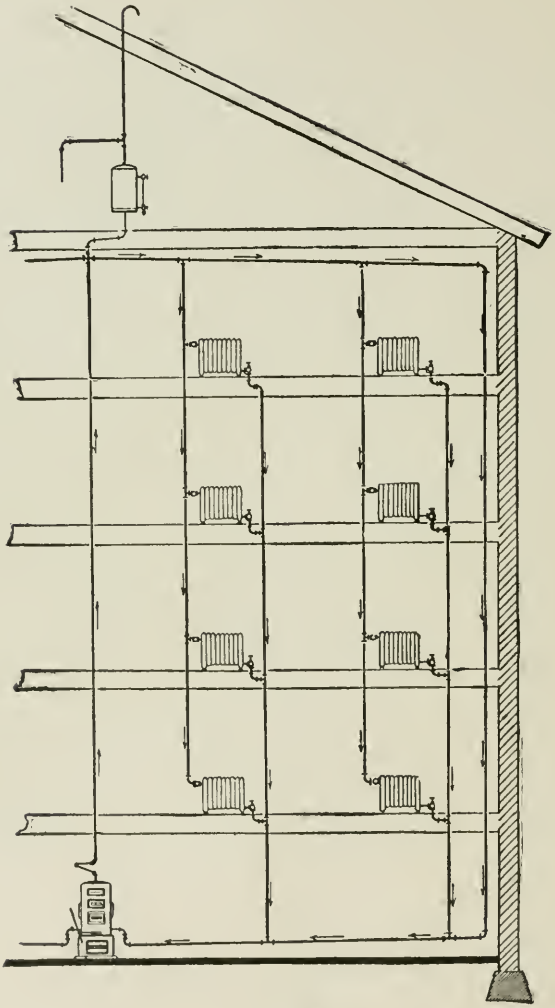


Fig. 253.

all supplied at the top, and, therefore, the air finds its way from all points to the expansion tank. This is, without question, a very good point to consider in constructing hot water heating plants.

By this system, as shown in Fig. 253, there will be the best kind of circulation of the water throughout the plant, without any difficulty, and in buildings where it is desirable to conceal the pipes they may be placed in partitions, while in public buildings it is often an advantage to have the pipes exposed, as, in the case of hotels, the pipes passing through small bedrooms are often hot enough to warm them.

In referring to the accompanying illustration I desire to call special attention to the main circuit in the system. As will be noticed after passing the supply connection to the second line of radiators, the main flow pipe continues over to the side of the building, and then drops to the cellar, and there connecting in with the other returns. This arrangement is for the special purpose of having a complete circulation from the highest to the lowest point, independent to the radiators, so that in case all the radiators happened to be closed, the boiler would be protected by keeping up the independent circuit. In the plant as shown the main flow pipe is carried from the boiler to the attic of the house, or to a point above the highest radiation, at the same time allowing over the boiler in this line for expansion and contraction, which can be done by placing in it an offset as shown. This relieves any strain, and makes the job more safe. The direction of the arrows indicates the direction of the water as it moves through the pipes in hot water plants of this kind. It may be noticed in referring to the illustration that the main horizontal return pipe falls below the bottom of the boiler and then rises to connect with the boiler; this is the best way to arrange the return pipe to any hot water heating boiler, for the reason that at times when the water in the boiler becomes very hot, there will be less chance for the return water to be pushed back with the effect of stopping the circulation. It regard to arranging the connections to and from the expansion tank in such an apparatus, it will be well to provide not only an outlet through the roof for the escape of steam, but also a branch just above the tank as shown, which may be carried to an open sink, so that in case of the water overflowing the apparatus, the water would not flow on the roof of the house, and another reason for having two outlets from the expansion tank is that the roof connection may freeze solid at times and, with but one outlet through the roof, there would be chances of damage to the apparatus from over pressure.

A Hot Water Heating Apparatus with Boiler and Radiators Located on the same Floor.

In stores and office buildings there is a large amount of hot water heating done where the boiler and radiators must be placed on the same level.

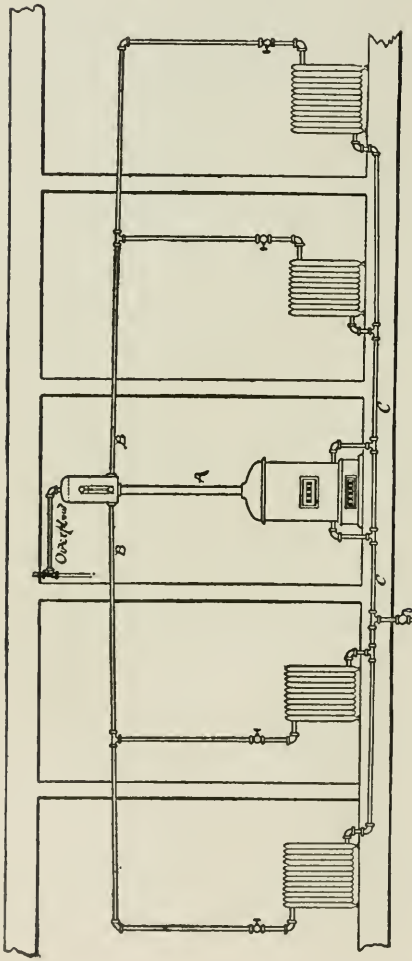


Fig. 254.

The illustration shown here represents a complete hot water heating apparatus, with boiler and radiators, located on the same floor level, and which give the very best results when carried out as shown. The drawing shows the boiler located in the center of the apartments to be heated. This is the best location for it in order to obtain the best results, but it may be located in any other part of the floor space if it cannot occupy a central position. The boiler may be located at one end of the store or apartments with satisfactory results.

In constructing a plant of this kind the flow pipe is carried from top of boiler direct to the bottom of the expansion tank, which in all cases of this kind should be located as high as the ceiling of the same floor will permit. Branches are then taken from the sides of the expansion tank near the bottom as shown, and the flow pipes to radiators from tank are carried

with a fall towards the radiators. The flow pipe A from boiler to expansion tank must, of course, have a capacity equal to the two pipes B B, which convey the water from the tank. Then, again, the return pipes C C, between the boilers and radiators under the floor, should also be of the same capacity as the two flow pipes B B. All other pipes shown in the illustration may be of a size smaller.

In order that any radiator in this system may be turned off while others are in operation, valves are placed on the supply pipe to each radiator as shown. The expansion tank should be equipped with a glass gauge so that the height of the water in it can be seen. With such a hot water system as shown here, care must be exercised in keeping the water at all times at least as high as the outlets from the tank, for the reason that should the water be allowed to fall below this point, there could be no circulation, and consequently no heat at the radiators. It is the best plan on such work to use an automatic water feeder on the tank. In all cases the tank is provided with an overflow pipe from the top, which should be open to the atmosphere and carried to an open sink.

By-Pass Connection in Overhead Supply Systems.

A special point in overhead systems for large buildings to which I desire to call attention, is the use of a by-pass connection at bottom of main flow pipe at boiler. It must be remembered that in starting up circulation in an apparatus where large bodies of cold water encountered in the flow lines, circulation will go slow until all water in the main rising line has warmed up, and for the purpose of quickening this circulation in starting up the apparatus, the value placed in by-pass connection at A, in Fig. 255, is opened which establishes a circulation first around the short loop made by opening the valve, and at the same time it allows the cold water in the main verticle flow pipe to fall through the by-pass to bottom of boiler, and thereby establishing a complete circulation in the main flow line, in the shortest possible time, and after the water falls through the by-pass connection warm, which will be an indication that the water is warm to top of rising main, the valve in by-pass connection is then closed and a rapid circulation immediately follows through the entire system. Another point which may be noticed by referring to Fig. 255 is the method of connecting the various radiators, and, as stated in other places, there are many ways to connect radiators and are used for various reasons, any of which that are shown will operate successfully.

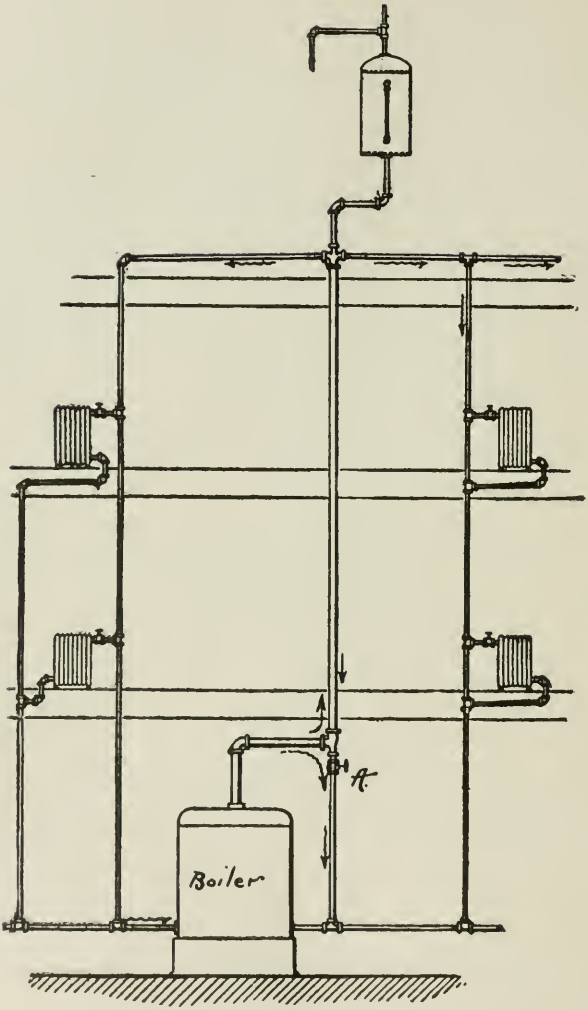


FIG. 255.

Combination Direct and Indirect Hot Water Heating.

With the better class of hot water heating plants, at least part of the radiation is indirect, and in connection with such an apparatus there are a

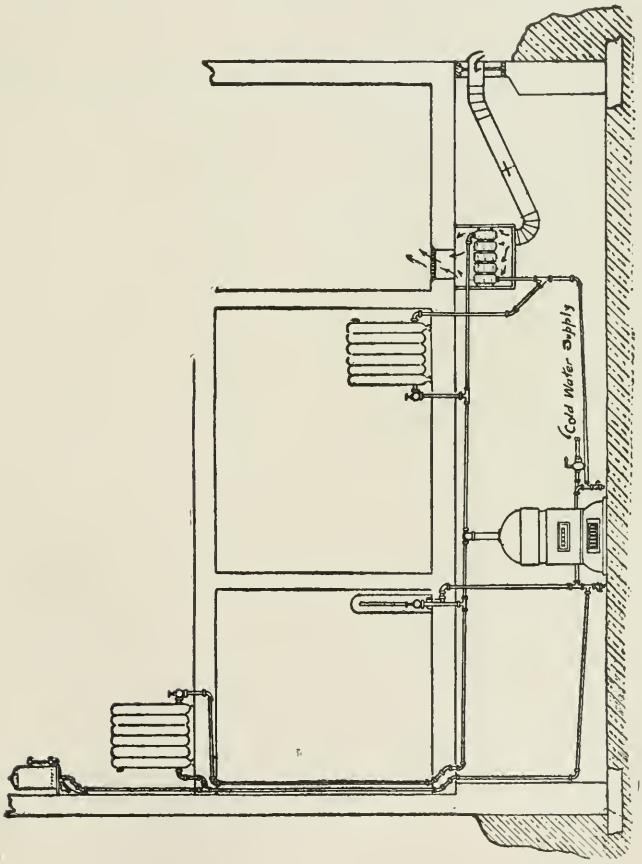


Fig. 256.

number of principles in running the pipes that should be of interest to the practical fitter. The illustration, Fig. 256, shows a hot water heating plant

with one indirect stack of radiators in the cellar for the purpose of heating the parlor of a house, two direct radiators on first floor, and one direct on second floor. In locating indirect nests of radiators, there should be at least from twelve to fourteen inches of space between the top of radiators and bottom of ceiling. Then with the thickness of the radiators and the necessary air space below them (which should be from eight to ten inches) brings the nest quite low down, especially for shallow cellars. And in very few cases is it possible to carry the flow pipe with a continuous rise from the boiler to the stack, as we do for direct radiators. And, therefore, we must supply the indirects, as shown in the illustration, by giving the pipe which feeds the indirect nest a fall from the point where it connects with the main flow pipe from boiler to top of indirect trap, and at the same time, if necessary, to locate direct radiators in rooms at points over this supply line to the indirect. Such radiators can also be supplied from the same source.

With the pipes connected to the indirect nest as shown, it will not be necessary to use an air valve on the indirect, for the reason that all air will pass along the main horizontal flow pipe and find its way to the direct radiator, where it will escape through the air valves of the directs. In fitting the cold air or fresh air supply to the indirect nest, it is a good plan to have the air enter at the bottom on the opposite end to that of the warm air outlet at the top as shown, thus giving the air an opportunity to travel over the greatest length of radiating surface. The size of opening in such cold air ducts for indirect nests of this kind should be about fifteen square inches for each ten feet of radiating surface in the nest. The air duct as well as the casing around the stack should be as near air-tight as possible in order that it may not receive the cellar dust and air. The mouth of the cold air duct on the outside of the cellar wall should be provided with a wire screen of about $\frac{3}{8}$ mesh, in order to guard against mice, large insects, etc. It is also a good plan to have over the mouth of the fresh air inlet a hood, so that rain or snow cannot be blown into the channel. A damper should also be placed in the cold air duct in order to check the air in very windy weather. I would not recommend the use of any valves to control the supply of water to indirect stacks, for the reason that with valves there are too many chances of having the circulation stopped, which would result in the freezing and bursting of the sections. Should valves be found necessary for indirect stacks, they should be cut on the seats, or drilled so that the entire circulation could not be stopped by turning the valves.

There is no end to the number of different situations met with by the practical fitter in constructing the hot water heating apparatus of a house, and oftentimes some of the situations met with are quite puzzling even to persons of much experience. In cases where a house is heated by both direct and indirect radiation there will be some good judgment necessary in arranging the lines of pipe in order to secure an equal distribution of the hot water. As the indirect nests are located in the cellar, it will not be as easy to cause the hot water to flow through them, no matter how they may be connected, as it will to get a good and quick supply through radiation above the cellar floor. One of these so called peculiar situations is shown in our accompanying illustration, Fig. 257, and was brought to the notice of the writer a short time ago while examining a hot water heating plant in a house on Madison Avenue, New York City. By referring to the illustration, it will be noticed that an indirect nest is supplied at the top of the first section, the supply branch is brought over from the main horizontal flow pipe and connected to the main by a tee, set at an angle of 45 degrees, a short nipple and a 45-degree elbow. The top of the indirect nest is as high as the main horizontal flow line; therefore, to connect as shown in the illustration, all the connections between the nest and the main flow pipe would be above both the nest and main cellar line, hence, this would be a good place for air to accumulate and stop the flow of water to the indirect stack.

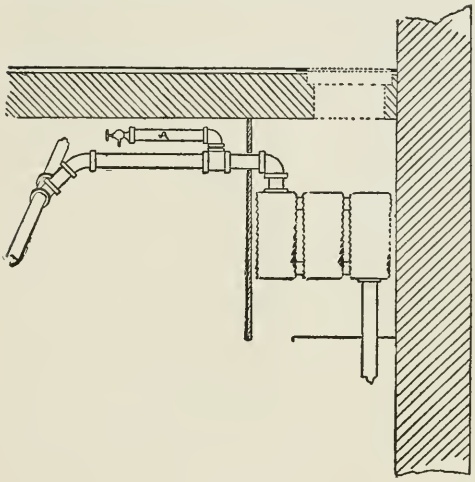


Fig. 257.

The air chamber shown is simply a piece of pipe capped on outside end and tapped for the air valve. The piece of pipe intended for the air chamber should be of good size, say one and a half inch or two inch, so that it will have

large air capacity. After the water is heated up a few times in a hot water plant, there will not be much accumulation of air to obstruct such connections as shown in the illustration, unless water is frequently drawn from the boiler and new water allowed to take its place. A hot water heating apparatus operates decidedly to the best advantage with old water, or, in other words, with water that has remained in the apparatus the longest time, for the reason that most of the air found in the fresh water will have escaped from it. The water is taken from the top of the main flow pipe, as shown, for the purpose of getting it at the highest possible temperature, and by doing so we force a circulation to the cellar stack as well as to direct radiators more favorably situated. In all lines of pipe connected with hot water heating plants, there is constantly going on what is known as local currents; that is, the water as a body not only flows in the direction intended by the heating engineer, but it sets up thousands of separate circulations all along the line. This will be more noticeable in horizontal lines. The water will be found to be much the hottest at the top of the pipe, and consequently flows more rapidly along the upper part of the pipe than it does in the bottom section. This is a good point that the practical fitter should try to remember in making any connection to horizontal mains. Tilting the branch tee on the main flow pipe as shown to an angle of 45 degrees gives us the water from the main as we want it at its highest degree of temperature, and at the same time it allows a much easier flow to the water over that of a 90 degree elbow, while the expense is the same in each case. Forty-five degree elbows are now being used quite extensively on both steam and hot water heating plants, and the reason is simply because the fitters in general are becoming more enlightened in regard to such matters, and after a little experience soon find out the advantages of improved fittings and fall in line in order to keep up with the procession of improvements.

Expansion Tanks and how They Should be Connected.

There is perhaps nothing connected with a hot water heating plant where there is more guess work and less actual figuring in regard to proper sizes than there is in selecting the size of expansion tanks. With the average practical fitter, judgment from practical experience is the rule carried out in selecting the size of the expansion tanks for the various plants, in something of the same manner as he figures the necessary radiating surface for the various

sized rooms. The man of large practical experience can, without doubt, make a close guess upon anything pertaining to his trade, but figures are the only things we know of that can be relied upon for accuracy. To know what size tank should be used on any particular job, we should first know the number of gallons of water the entire heating system would hold, and as water expands in a rise of temperature form 40 to 212 degrees Fahrenheit, one in twenty-five

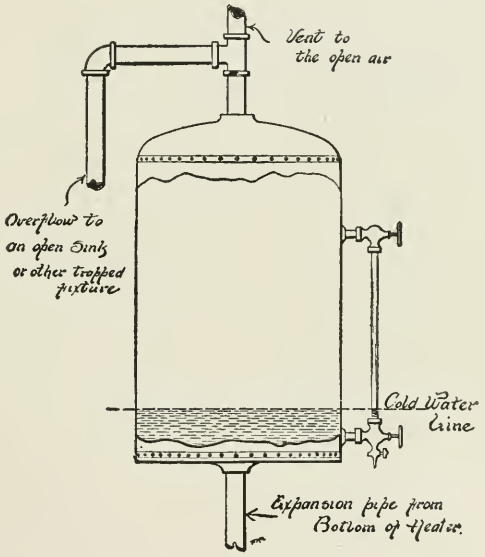

Vent to the open air
Overflow to an open Sink or other trapped fixture
Cold Water Line
Expansion pipe from Bottom of Heater

FIG. 258.

parts, it would, therefore, be necessary to make provision for about one-twenty-fifth the entire capacity in the size of the expansion tank. The special object of the expansion tank on any hot water heating apparatus is to prevent any waste of the water, so that after the system is once filled, it will remain so without loss except that which might come from the evaporation of water escaping through the overflow connection of the tank. Of course there is chance of losing some of the water by leaks in the pipes, radiators and in the boiler at

times, but this we do not calculate on in good work, and especially after the plant has been in operation long enough to cause every joint to become perfectly tight. There is a loss of more or less water through air valves, which also draws from the expansion tank, and which should be avoided as much as possible. The proper location of the expansion tank is at any point above the highest radiator in order to keep the entire system full of water; the tank should be provided with a glass gauge so that the occupants of the house could see the line of water in it. Referring to the illustration, Fig. 1, which represents an expansion tank with top and bottom connections and glass water gauge, the level of the water is shown. This would be the point at which the water should stand when the water in the apparatus is cold and before starting the fire, for the reason that we cannot tell the system is full until we see the water at the bottom of the glass gauge; and, therefore, in figuring the necessary capacity of tank for the expanded water, we cannot take into consideration the portion of the tank from the cold water level down as shown in the illustration. The next question is, how are we to know how much water the system holds in order to make proper allowance in the expansion tank? and in reply to this question I would say that there are two ways of finding that out; the first and most simple plan is to fill up the system after it has been completed with the exception of connecting the expansion tank, and then draw off the water again, carefully measuring it with a gallon, or some other convenient measure, and dividing the number of gallons by twenty-five, and using a tank large enough to hold one-twenty-fifth the amount, plus the capacity of the tank below the water line, as shown in the illustration. The other way of finding out the size of tank is to figure out the cubical contents of the pipes, radiators and boiler. This is not an easy matter to do, but it can be done. The fitter should find out from the boiler-maker the number of gallons of water each size boiler holds.

The fitter should also know the capacity in gallons of radiation used, and with a table of cubical capacities of different sized pipes, the total water capacity of the plant can be found. A good hot water radiator holds one pint of water per square foot of radiating surface. This is a safe figure to go by, and is about the same as the capacity of a 1-inch steam pipe per foot of outside surface. For example, 1.67 feet of standard wrought iron steam pipe will hold one cubic foot of water, which is about $7\frac{1}{2}$ gallons, and for practical purposes we figure 3 feet of 1-inch pipe for one square foot of outside surface, so that

167 lineal feet of 1-inch pipe will give us 55 square feet of surface; this number divided by 8, which represents eight pints, or one gallon, gives practically seven gallons.

To make close calculations on the expanding of water in a hot water heating apparatus, we must take into consideration the fact that as the boiler, pipes, and radiators become warm, the cubical capacity of the entire apparatus becomes larger and therefore makes room for some of the water, but this is such a small amount that it is not considered in general practice. It is therefore a good plan to make ample allowance in selecting an expansion tank, for the reason that it acts as storage reservoir, and when not supplied automatically will require much less attention than would be found necessary with a smaller size. Another special reason why expansion tanks should be either supplied automatically or of good large capacity is because the water often leaks in the fire surface of boilers, and which is never noticed by the occupants of the house, as it forms into steam and escapes with the smoke through the chimney. This the writer has especially noticed while practically engaged in hot water heating with wrought iron tubular boilers. For open tank hot waterheating, the expansion tank it practically the safety valve for the entire apparatus, and therefore should receive careful and special attention.

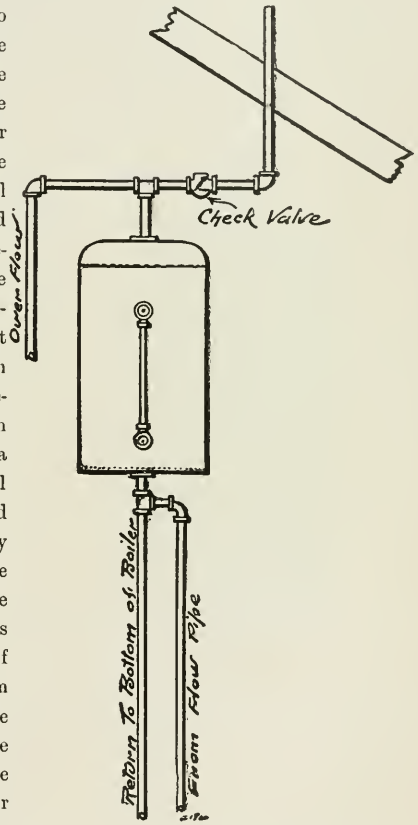


FIG. 259.

In regard to how it is connected and where it may be placed. For ordinary sized house work, the expansion pipe or bottom connection from the tank to the bottom of boiler should never be less than one-inch pipe and in no case should this pipe be fitted with a valve of any kind.

THE FOLLOWING TABLE GIVES THE NUMBER OF FEET OF STANDARD WROUGHT IRON PIPE THAT WILL HOLD ONE CUBIC FOOT OF WATER.

⅛in..... ...2500.	1¼in..... 70.65	5 in..... ... 7.20
¼in..... 1385.	2 in 42.36	6 in..... ... 4.98
⅜in..... 751.50	2½in..... 20.11	7 in..... 3.72
½in..... 472.40	3 in..... 19.49	8 in..... 2.88
¾in ..... 270.	3½in..... 14.56	9 in..... ... 2.26
1 in..... 166.90	4 in..... 11.31	10 in..... 1.80
1¼in..... 96.25	4½in..... 9.03	

Expansion Tank with Check Valve on Escapement Pipe.

If expansion tanks are located in places that might under any possibility freeze, they should be provided with circulating connections as shown in illustration, Fig. 259, at bottom of tank, one pipe is carried from a flow line as marked while the other connects with bottom of boiler. Thus a circulation is kept up as long as there is any heat in the water, which keeps the water in tank warm.

The Check Valve in the Outlet Connection Through Roof.

Some very prominent heating engineers place check valve as shown in Fig. 259, on the roof connection above tank for the purpose of preventing water at times when it boils being forced on to the roof of the house, while at the same time, as will be noticed by the position of the valve, it will allow air to be drawn from the roof pipe in case of a vacuum being found in the overflow pipe, and thereby preventing water being pulled from the system. This little feature looks well at first sight, but should the roof connection freeze up, and the water overflow the tank, a siphon would take place and the water pulled from the system through the overflow pipe.

A Reliable Method of Expansion Tank Connections.

A method of connecting expansion tanks produced by the writer which can be relied upon and having none of the objectionable features mentioned is shown in illustration, Fig. 260.

In this arrangement of piping the usual method of producing a circulation of the hot water to the tank is carried out as shown, but the overflow connections are different from that usually employed heretofore. In this method there is no pipe passing out through the roof from the tank, but two pipes are carried to an open plumbing fixture as shown, one marked A in illustration is the overflow pipe, while the other pipe marked B is the air pipe

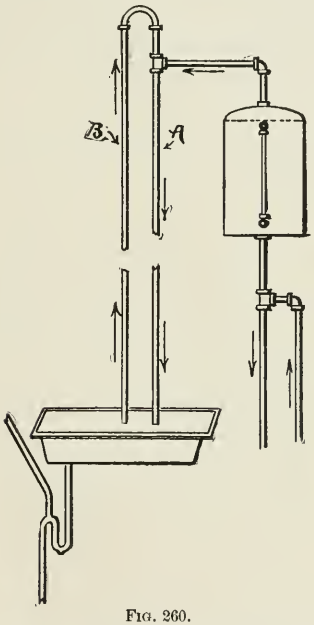


Fig. 260.

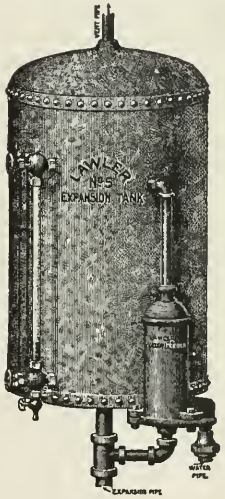


Fig. 261.

which carries air to top of overflow pipe for the purpose of preventing siphoning. The system shown in Fig. 260 may be a little the most expensive in some cases to construct, as two pipes are to be carried to the open sink, but the advantages in this system will more than pay for the difference in expense.

In illustration, Fig. 261, we show what is known to the trade as the Lawler automatic expansion tank for hot water heating plants. In this system of tank the water supply is connected to the automatic water feeder on side of tank as shown, this feeder allows the supply water to fill up the system to the

bottom of tank when it closes, thus keeping the heating system filled with water at all times without requiring any attention. By this system as shown in Fig. 261, the full capacity of the expansion tank can be used for the expanded water as the feeder can be set to stop the supply of water at any height. This tank being riveted on the head as well as the bottom cannot leak from any overflow of water or steam; it is therefore more reliable to be placed over ceilings. The top or overflow connections from this tank may be connected in the best manner as described in Fig. 260, or any other way that the heating engineer may desire.

The following table of sizes and capacities of the Lawler Expansion tank as shown in Fig. 261, will enable the fitter to tell what size tank will be required for any ordinary sized job. These ratings include the water in the boiler and pipes as well as the radiating surface.

THE AMOUNT OF RADIATION EXPANSION TANKS WILL CARRY.

NO.	SIZE	Capacity in Gallons.	Capacity in Square Feet of Radiating Surface, Each Tank will carry.	NO.	SIZE	Capacity in Gallons.	Capacity in Square Feet of Radiating Surface Each Tank will carry.
0	10x20	8 Gallons	260 Sq. Ft.	7	16x30	26 Gallons.	900 Sq. Ft.
1	12x20	10 "	350 "	8	16x36	32 "	1100 "
2	12x24	12 "	450 "	9	16x48	42 "	1350 "
3	12x30	15 "	525 "	10	18x60	66 "	1850 "
4	12x36	18 "	650 "	11	20x60	82 "	2500 "
5	14x30	20 "	750 "	12	22x60	100 "	3000 "
6	14x36	24 "	850 "	13	24x60	120 "	4000 "

SUPPLYING HOT WATER HEATING PLANTS AUTOMATICALLY WITHOUT EXPANSION TANKS.

The accompanying illustration shows how small hot water heating plants are now fitted without expansion tanks with the best possible results. As a rule, all houses heated with the hot water system have bath-rooms, and these rooms must also be heated, therefore a small radiator is located in the room, and if there are no radiators located in rooms above the bath-room, the water supply to the heating apparatus may be made as shown in the illustration.

All that is necessary in regard to the supply of water is to have the

system filled a little above the highest radiation at all times, in order that the hot water will circulate through the highest radiators as well as those situated at lower points throughout the house. In small hot water heating plants, such as may be erected in ordinary sized dwelling-houses, the amount of water wasted by expansion would practically amount to nothing in regard to the waste of fuel, for the reason that the greatest expansion of the water takes place when the fire is first started in the fall, and as a rule not allowed to go out, until spring. The fire may often go out or the temperature of the water in the apparatus allowed to fall quite low through carelessness, and under such circumstances the only trouble would be in keeping the apparatus full without an expansion tank or some other means of supply. This other means of supply is what takes the place of the tank, which is simply an automatic water feeder fitted with glass gauge, and located a little distance above the bath-room radiator as shown. The expansion pipe is taken from the return connection of the radiator below the floor and carried up to the bottom of the water feeder, and continued from the top of feeder to top of water-closet tank, where the little amount of water from expansion may escape.

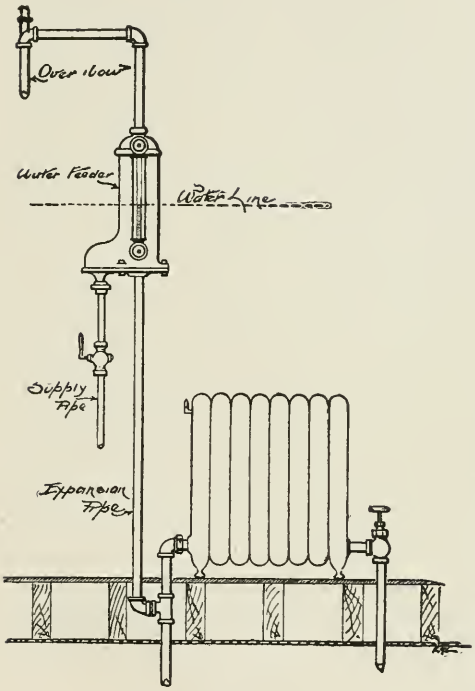


FIG. 262.

Then in regard to connecting the cold water supply to the feeder, this will be found to be convenient to the supply of the plumbing fixtures, and may

be taken from any one of these cold water connections, placing a stop-cock at any convenient point as shown. Perhaps the best point in an apparatus of this kind is that there will be no possible chance of the overflow connection freezing, as it is situated in a heated room. If there are radiators located in rooms above the bath-room, this same arrangement can be carried out by simply connecting the feeder as shown, and having it located close to some radiation, carrying back the overflow to the nearest waste pipe or open fixture. Of course, with such an apparatus it will be necessary to have a water supply system, otherwise the automatic feeder would be of no use. With any automatic supplied hot water heating system, it would be the best practice to carry down to the bottom of the boiler a separate pipe in place of connecting at the radiator as shown for the reason that, when cold water would enter the system from the feeder, it would not interfere with the circulation of the hot water; still this would not amount to much on small work. To abolish the expansion tank and use the automatic water feeder as shown in the illustration would be improving the apparatus by making it automatic as to its water supply, besides making the work less sightly, and without increasing the cost. Another special point in favor of the automatic water feeder without the expansion tank is that in cases where water is drawn from the heating apparatus for other purposes the feeder would keep up the supply without attention from any person. It often happens that in *cellars* there is no place to draw water for any purpose except from the heater, and ashes are sometimes sprinkled. Hot water for scrubbing and cleaning purposes of other kinds is drawn from the boiler draw-off cock, and under such circumstances the automatic supplied system is the only practical plan.

The Regulation of Heat.

The question of heat regulation is a very important one from many points of view, and it makes but little difference what system we use in heating our homes, schools, and places of business, the subject is worthy of more careful consideration than it has hitherto received at the hands of the trade. We may have the hot air, the steam, or hot water system and each may be the best of its kind and first class in every way as regards supplying a sufficient amount of heat, and yet without some effectual means of controlling and regulating the amount of heat furnished, any system will be not only dangerous and unsatisfactory in many ways and on many occasions, but there will also be a very large percentage of fuel wasted.

Proper Regulation Conducive to Health.

Let us consider the advantages of a heating plant so arranged, if possible, that we would not only get a sufficient quantity of heat to properly warm the house in zero weather, as called for in most heating specifications, but that would also give us the proper quantity and quality at the proper times. A means of perfectly regulating heating systems for dwelling-houses, schools and business buildings, would be one of the greatest of modern achievements conducive to the health and happiness of the human race. I am satisfied that no person who has given due consideration to the subject of heating and ventilation will disagree with the above assertion.

Rapid Progress of Later Years.

There was not much accomplished in the line of heat regulation until the past four or five years. Why? Because it is one of the most difficult problems that the heating engineer has had to face. This is an age of invention in which the brightest and most talented men in every line of trade are doing their best to set the pace in the march of progress. The heating engineer has not been sleeping, and, although he has not yet completed an entirely perfect heat-regulating system, he is moving in that direction with as much speed as that attained in other directions of equal importance.

Proper Heating.

When is a house properly heated? A house is properly heated when the atmosphere of the different rooms and compartments in it is at the temperature best suited to its occupants. Without regulating fixtures of some kind, even with the best apparatus available for heating by any method, how long would the occupants of the house be likely to enjoy the proper temperature? Scarcely long enough at a time to know that such a thing had happened. The aim of heating engineers is to construct and equip their heating plants that will automatically give out the exact amount of heat necessary to maintain the desired temperature throughout the house at all times, no matter what changes may take place in the temperature of the outside atmosphere. To secure a perfect heat-regulating system is not only the aim of the heating engineer, but it is also—which it should be—the desire of all intelligent householders. Many of the ills to which flesh is said to be heir would be avoided if we lived in houses in which the air was pure and of a uniform temperature throughout the season. A good heat-regulating system does more to prolong the lives and

add to the happiness of the persons who live in houses thus equipped. It preserves the house itself, and prolongs the life of the boiler, the heater, or the furnace to which it is connected. In fact, every part of the entire heating plant is more or less protected by a good heat-regulator. If we consider heat regulation from an economical point of view, we will be favorable to it, for the reason that where a good heat-regulating system is installed there can be no waste of fuel by keeping the temperature of the house too high. Operating a heating plant without proper regulating fixtures is as wasteful as it is heating a large building with live steam under power boiler pressure, and allowing the exhaust steam to escape.

An Effective Hot Water Regulator.

Hot water heating systems which have many advantages over all others, are weak in one point. Proper automatic regulation is lacking. It is strange that architects, fitters, and owners of buildings, do not give more attention to this very important matter, and secure some means of automatically regulating hot water heating plants.

Hot Water Damper Regulators.

In illustration, Fig. 263, we show a hot water damper regulator attached to the flow pipe of a boiler by a single connection; this regulator is partly filled with water, which water is made to boil by the water from the flow pipe passing around an outer shell. As the boiling point of water is higher the greater the pressure on it, there will be a difference between the boiling point of the water in the inner chamber of the regulator, Fig. 263, and the water in the heating apparatus, because the water in the regulator has no pressure on it when cold, as its diaphragm is open to the atmosphere, while the water in the heating system at the boiler must have the pressure due to its height, which will be several pounds

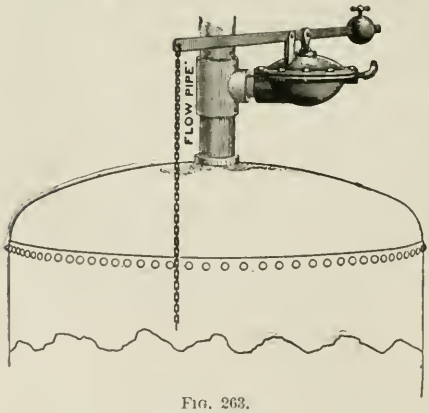


Fig. 263.

in the ordinary house plant. Therefore, as the temperature of the water in the flow pipe from heater rises to 212 degrees it will heat the water in the regulator to the same degree, and this water being open to the atmosphere will begin to boil and form steam which will lift the diaphragm of regulation and close the draft doors to heater long before the water in the heating apparatus will boil, yet the water in the flow pipe may be even several degrees warmer than that in the regulator, but on account of the pressure which it is under, due to the height, this water will not boil until its temperature rises many degrees above that in the regulator. Therefore, this is what might be called a limited device, as it will not operate until the water in the system rises to a temperature above 200 degrees, yet this is a good device for heating plants, where the radiating surface is small for the work to be done, and the temperature must be kept high, by the use of this regulator, Fig. 263, there will be no fear of the water boiling in the apparatus.

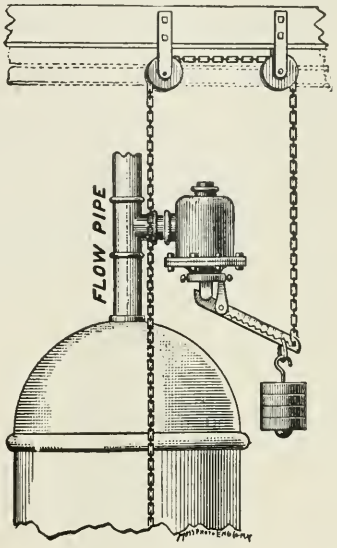


Fig. 264.

Compressed Air Hot Water Damper Regulator.

In Fig. 264, we show a regulator for controlling the draft doors of hot water heaters by the temperature of the water in the apparatus, and which, when nicely balanced with light weight doors, will operate at any temperature from about 120 degrees up. This regulator is applied to the flow pipe of the heater by one connection, as shown, which is a close two-inch nipple; as will be noticed in this regulator the diaphragm is reversed, being at the bottom, and it operates as follows. On the inside of the cylinder there is a coil of small pipe which measures about 75 feet long, and which, if sealed at one end, and open to top of diaphragm at the other end, the water from the heater surrounds this coil and as the water heats it radiates through the walls of the

tube and also heats the air in the tube, this causes the air to expand and this expansion force is exerted on the diaphragm, which again operates the lever and closes the draft door. As the water cools the air also cools and contracts, which reduces the pressure on diaphragm and the draft door opens again.

Hot Water Damper Regulator Operated by the Expansion of Water.

In illustration Fig. 265, we show the Lawler Hot Water Damper Regulator which operates by the expansion of water in a small brass tube. This regulator will operate at any temperature above 100°, and it can be adjusted to any

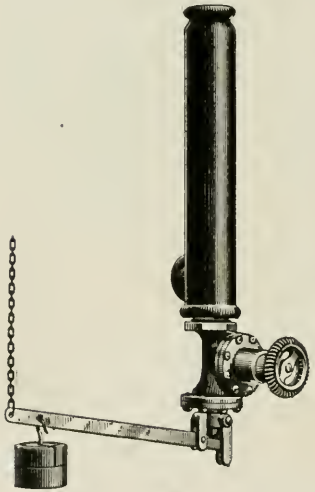


Fig. 265.

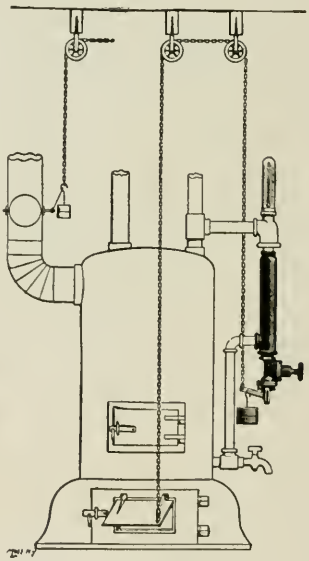


Fig. 266.

desired temperature by operating the adjustment screw as shown on side of regulator. There are many methods of applying this regulation to a heating system that will operate in a satisfactory manner, and we show, in Fig. 266, one method of connecting same.

This regulator is without question the most perfect device yet produced to operate draft doors on dampers by simply the rise and fall of temperature in the water, and without any other means of motive power. It has unlimited power, and therefore can be used on any weight draft door.

Regulating the Temperature of Water Heated by Steam.

In illustration, Fig. 267, we show the Lawler Thermostatic regulator for hot water tanks. This is practically the same device as described in Figs. 265

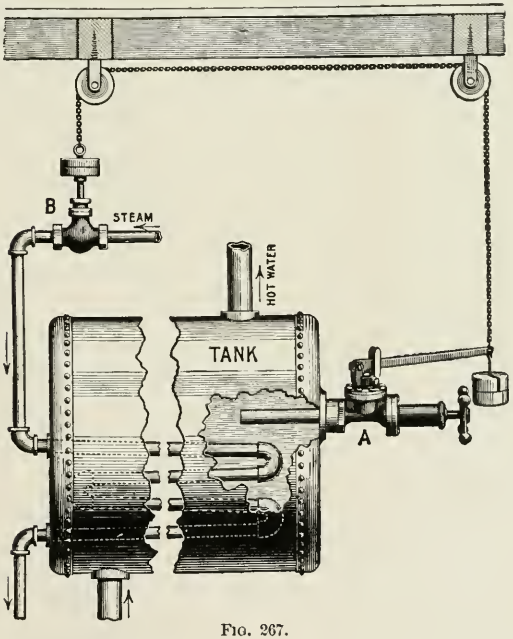


Fig. 267.

and 266, but it is used for another purpose; in this case it operates a balance valve in the steam supply to coil in place of a draft door. This regulator can be applied to any make of hot water tank, which is a most important feature, it

can therefore be applied to old tanks already in use and with very little expense. A special point that should be considered by those who have use for such a device, is that the steam supply valve to coil may be placed in any location that may be desired, thus saving both material and time in making connections. Referring to illustration, Fig. 267, A represents the thermotatic regulator screwed into one end of a hot water tank and requires a 1¼ inch tapping. B in the illustration is a balanced valve placed on supply pipe to steam coil, and having sufficient weight to its stem to overcome any friction in stuffing, box on valve and allow the valve to close when the lever rises on A. The temperature of the water can be regulated to any desired degree by adjusting the four-armed handle shown on end of regulator A.

Special Fittings for Hot Water Risers.

Hot water heating plants for any kind, style or size of building, one of the most important, as well as the most difficult problems with which the heating engineer must contend, as before stated, is the equal distribution of the hot water. There are very few situations met with in general practice where it will be both convenient and practical to have the boiler located in a central position to the radiating surface of the heating apparatus. And even should such a case be met with, it would only benefit horizontal lines which take care of the radiating surface of one floor with the ordinary way of piping and by the use of regular style fittings. Even with the boiler located in a central position, with plants having long risers to feed radiators on different floors, there will be difficulty in getting an equal supply of hot water on each floor. As the specific weight of water is less the higher it rises in temperature, the hottest water or the molecules thereof, will have the greatest buoyancy power and will, therefore, have a tendency on this account to ascend in the most vertical position, or to the highest point in the riser. To overcome this great principle in nature, and cause as much hot water from the riser to flow into the lowest radiator, as the natural tendency would cause the hot water to flow into the radiator situated at a higher elevation, is a nice point to consider, and any special means of improving this condition of things should be of value and interest to those engaged in the constructing of hot water heating plants.

The illustrations, Figs. 268, 269, and 270, show the different lines of risers and returns, connected to direct radiators on four different floors, and they

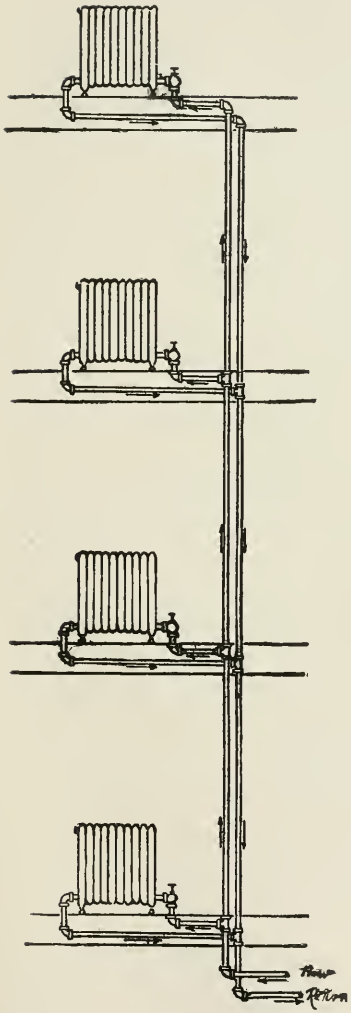


FIG. 268.

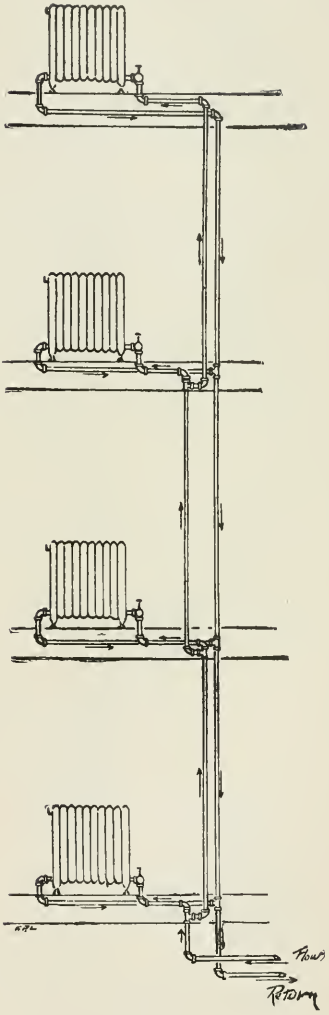


FIG. 269.

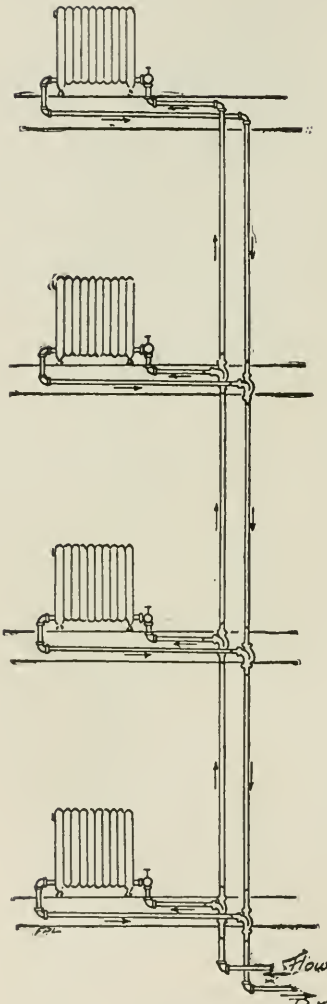


FIG. 270.

each represent a method of how pipe work is done in hot water heating plants. As may be noticed in referring to illustration Fig. 268, the branches to the various radiators are taken direct from the vertical lines by single tees, and allowing the flow water to enter the nearest end of each radiator for a moment we will consider what we may expect in the action of the water circulating through such connections. In running such lines of pipe we would naturally reduce the sizes the higher we would carry them, according to the number of feet of radiating surface to be supplied, yet this would not give us an equal distribution of the hot water, and under such conditions the radiators situated on the highest floors would be found to be the warmest. This action not only draws away the hottest water from the lower radiators, but on account of the water circulating more rapidly through the upper radiators, it has the effect of still further retarding the movement of the return water from the lower radiators. Therefore such a system of risers cannot be recommended.

In Fig. 269 we have a modification of the system showing Fig. 268, which has advantages over the latter; still while this is a slight gain in regard to the more equal distribution of the hot water, there is an additional expense added by the use of an extra number of fittings as well as extra labor. And another objection is in the additional

friction added to the flow of water which, when taken into consideration, is a question whether, on the whole, there is any real gain in the action of Fig. 269 to that of Fig. 268.

In Fig. 270 we show what is without doubt the most up-to-date system of connecting up radiation for hot water work on long vertical lines of pipe. This system not only gives an equal supply of hot water to the various radiators on different floors, but it will give less resistance to the movement of both the flow and return water, and without any additional labor over the simple, straight connections, as shown in Fig. 268. The improvement of circulation and equal distribution in system, Fig. 270, is due to the use of special combination fittings placed on the flow and return risers from which the branches are

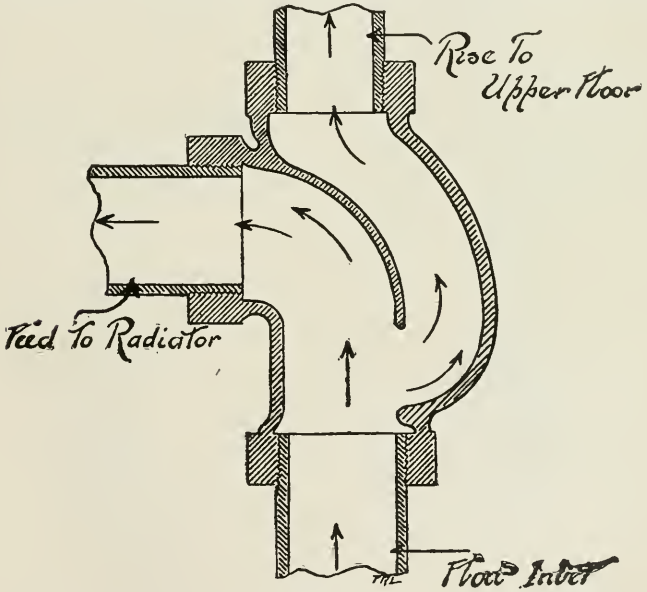


FIG. 271.

taken to the radiators. A sectional view of this special fitting is shown in Fig. 271, and although used for some time by many leading fitters and heating engineers throughout this country, its real principle and merits are not generally known. The object of this improved fitting is to divide the vertical

flow of hot water and cause it to be delivered through the branches on any floor at the same temperature. This is accomplished by a partition which extends from the upper part of the fitting to a point below the bottom of the side outlet, thus deflecting the rising current to one side, which supplies the radiation on floors above that which is fed from the side outlet. The long sweep to the curves in this fitting, although acting in the capacity of a tee, reduces the friction to that of a long sweep elbow, and without taking up as much room. This special hot water fitting has also the advantage in appearance, which amounts to something in exposed places. It is known to the trade as the O. S. distributing fitting for hot water heating.

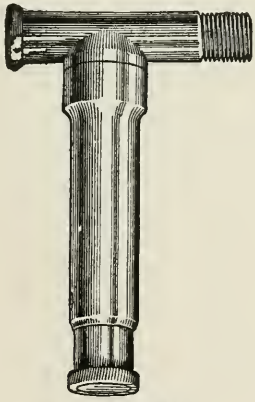
Automatic Hot Water Air Valves.

It is of the utmost importance in hot water heating plants to prevent air and gas accumulating in the system, because air will stop circulation of the water in flow and return pipes if allowed to remain at any point, besides air and gas, when allowed to accumulate in radiators, reduces the capacity of the radiating surface and often prevents water from circulating through any part of a radiator. There are many situations met with in practise where it is necessary to use air valves on radiators and other parts of the heating apparatus, and when such valves are non-automatic and must be operated by hand it will be found that they will be neglected and the apparatus run at a great disadvantage more than half the time. It will therefore be seen that a reliable automatic air valve that will allow air and gas escape from hot water heating systems without allowing water escape is a most important appliance for such heating systems. And while there has been many attempts from time to time to construct such a device that would meet the approval of heating engineers and architects, the problem remained unsolved until a year or so ago when the device shown in the accompanying illustration, Fig. 272, was produced. All efforts to produce a reliable automatic air valve for hot water systems heretofore were carried out on the same old principle of using floats to close the valve against the escapement of the water after air escaped from the system, some acting in a direct manner with the valve, while others had floats pivoted to combinations of levers but in no case did such systems prove successful.

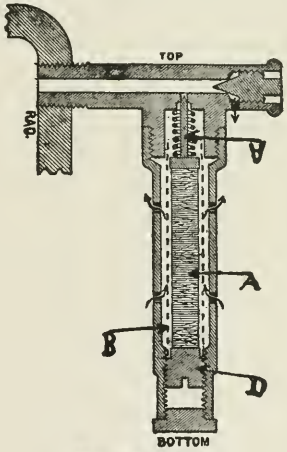
To secure sufficient power to close a valve against such water pressure as that which is found in the average hot water heating plant, by means of a float, would require an area in such float of too great a size to be practical on

radiators, hence any small valve, or a valve of three or four inches long and even two inches in diameter with a float of same size to close the valve in water radiators, cannot be reliable, because the power to close the valve being only part of the buoyancy of such float is not sufficient, and the least friction to such float would render it worthless. Therefore, to produce a valve for hot water heating plants, that would be absolutely reliable against any pressure of water and operate automatically, allowing all air and gas escape from the systems without allowing water to escape, and at the same time of such small size that would be practical, and neat in appearance, made it necessary to work on a new principle and discard the float.

The new principle therefore of automatic hot water air valve operates on the expansion and contraction of a lignus substance which gives it unlimited power to close the valve, and has proved eminently successful from every point of view



The Floatless Water Air Valve.
FIG. 272.



Section of Valve.
FIG. 273.

The illustration, Fig. 272, is a full sized view of the LAWLER FLOATLESS HOT WATER AIR VALVE mentioned above, while the illustration, Fig. 273, is a sectional view of same, and it operates as follows:

In applying this floatless hot water air valve, it hangs down as shown in illustrations. It is provided with a direct or positive valve at top which is operated by a key for the purpose of allowing air escape quickly when filling

the system and save time thereby. The valve in this device, which operates automatically, is shown at V in illustration, Fig. 273, the upper end of which is ground to fit a very small opening in upper section. The valve therefore is on the outside of the pressure in a similar manner to the direct opening valve operated by key, the valve V rests on the expanding pillar A, and the valve V is held in proper distance from its seat by the adjustment screw D under pillar A. The pillar A is surrounded by a perforated brass tube marked B in illustration, Fig. 273, and this is for the purpose of keeping the expanding pillar in perfect line, so that when it expands it must expand in length and at the same time the tube B acts as a guide passing into the large socket on top which holds valve V keeping the valve also in a proper vertical position. When the automatic part of this valve is set, it is left open a very little. As air rises in the radiator it passes out through the valve opening controlled by V, and after all the air has passed out the valve being still open for a moment or so a drop or two of water passes out also. These drops of water fall down in the perforated tube, and as they do so the expanding pillar A is made moist from the water, and the pillar absorbing these few drops of water immediately expands pushing up the valve V and closing the opening from the radiator. The automatic valve being now closed against the escapement of air or water will remain so until the moisture which has been absorbed by pillar A has evaporated, when the pillar will again contract, shortening its length and allowing valve V to drop away from its seat, when the air, if any, will escape from the radiator, and following the air a few more drops of water will again find its way to the pillar A, where absorbed again by the pillar and closing the valve. To allow for the escapement of moisture in the expanding pillar, the shell or casing is provided with ventilating holes, some near bottom and some located near top of casing; these holes allow the heated air surrounding the radiator to flow in at the bottom and pass out at top as indicated by the direction of the arrows, and which heated air carries with it the moisture or evaporation from the expanding pillar, thus causing it to dry and open, so that the valve is practically in operation at all times, being in the act of either closing or opening at all times. This valve adapts itself to the conditions of the heating plant, because the higher the temperature of the water is carried in the heating apparatus, the more frequent the valve will open and allow all air to be expelled; while with the water cold in the system the valve will remain closed for a much longer time.

Special Valves and Pipe Systems for Hot Water Heating Plants.

THE SIMPLEX HOT WATER RADIATOR VALVE.

This valve makes it possible to produce a good circulation of the hot water through radiators by the use of one opening of the radiator, and thereby dispensing with the usual return union elbow. By placing this simplex valve on radiators there will also be a saving in pipe the length of the radiator, for the reason that the valve will be placed on the end of radiator nearest the flow line. There is also economy in the use of these valves in the saving of time in making connections and the cutting of floors, but the best point to be noticed in this valve is that by its use there will be a much better circulation of water through the radiator, than where a separate return connection is used on opposite end of radiator such as that usually practised heretofore.

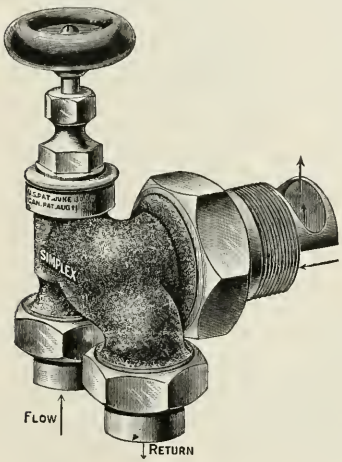


Fig. 274.

Fig. 275 gives a sectional view of the simplex hot water radiator valve, which will be noticed is divided in the center by a partition, which allows the flow water to pass on the upper side while the return water drops back into the return connection on lower side of partition as indicated by direction of the arrows in cut.

The reason why a better circulation of water is produced where these valves are used, is because the flow of water can only enter the first loop in any radiator, thus flowing rapidly to the top and returning through all the other loops as indicated in the sectional illustration, Fig. 276, by the arrows.

The end of the valve which enters the radiator is of two inch size and which extends into radiator as shown the distance of one loop. It takes much less time to set hot water radiators by this method, as it is about the same as the one-pipe steam connection as regards time and simplicity of connecting. Radiators are to be disconnected at times, and with this there will be but one union to disconnect, and where radiators, either steam or hot water, are con-

nected at both ends it will be found to be a much more difficult matter to get the correct measurements to fit in the first place, and much more trouble will be experienced in disconnecting the two pipes when necessary.

A modification of the valve just described for hot water is shown in Fig. 277, and is used for steam work where the two-pipe system is used. The difficulty experienced in steam work where two valves are used, one on the supply and the other to control the return, is obviated by the use of the simplex steam

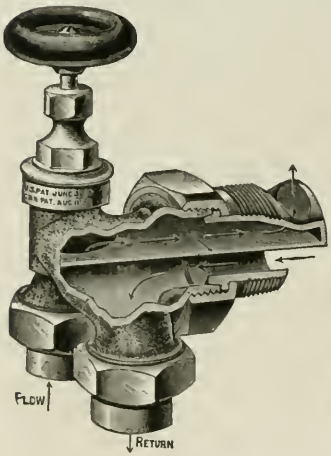


FIG. 275.

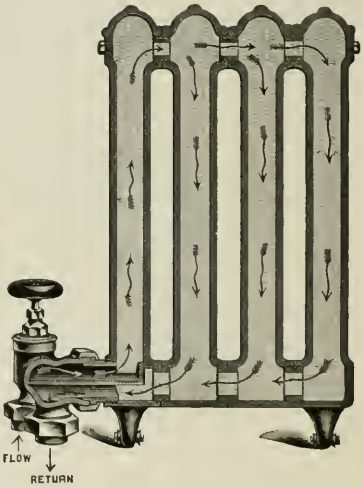


FIG. 276.

valve, as there is but one handle to operate and the flow of steam to the radiator cannot be shut off without closing the return at the same time, and therefore condensation cannot back up into radiators equipped with such valves.

The illustration, Fig. 278, shows this simplex steam valve applied to a radiator, and as will be noticed the nipple of this valve does not extend into the radiator as far as that of the valve for hot water, neither is it provided with a stop on inner end of nipple but left open to all sections as shown.

The simplex radiator valves described above are the inventions of Mr. C. J. Balthasar, of New York City, who is an expert in steam and hot water heating of much ability and well known to the author.

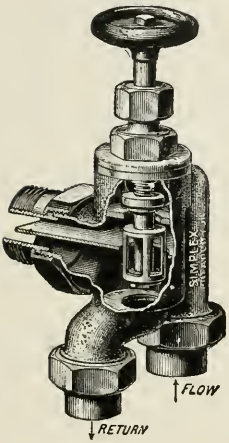


Fig. 277.

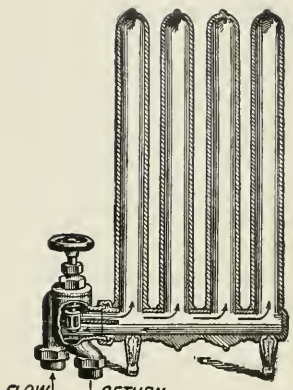


Fig. 278.

How to Construct Long Horizontal Flow Mains in Hot Water Heating Plants.

In constructing hot water heating plants for scattered buildings where all radiation is supplied from one boiler, or a group of boilers coupled together, there must be some careful calculations made in the laying out of the pipe work in order to secure a good circulation at all points throughout the plant, and for the purpose of showing how this can be done in a successful manner, we make use of plate H C, which is the working drawing of a large hot water heating plant now in operation and giving the most satisfactory results.

We merely show in plate H C the cellar mains connected to boiler, but branches are taken from top of flow lines to the various radiators and risers with returns carried back to side of same flow lines. Referring to the plan, it will be noticed that the main flow from boiler, connects with a tee which separates the flow water to each side of the boiler as it is located, and this tee is the highest point in the cellar system of main pipes. We will now follow the flow line on the right marked A, and the direction of the arrows will show the direction in which the water moves. The first tee over the boiler being the highest point we begin to pitch down from this point, and as will be noticed in a distance of 6 ft. we have a fall of ½ inch to the first angle or

elbow, we have now a run of 46 feet and in this distance we pitch down 4 inches, we now come to a bend in the line which is 5 ft. long and we give this a ½-inch pitch, and the next long stretch is 18 ft. which is given 1¾ in. pitch, At this point we place a tee on the line with the outlet looking up, with the end of this tee connecting by a 6-ft. piece of main pipe to the side of the return as shown, and this offset is pitched ½ inch, and which practically completes the first circuit. It will now be noticed that as far as we have gone with this main flow line to the first tee looking up we have dropped 6¾ inches, and to continue further horizontally we rise from top of this tee just described the same distance which we pitched down from boiler, which is 6¾ inches, and then extending the main flow line as will be noticed a distance of 46 ft. more, with a pitch in this distance of 4½ inches connecting with another tee, we rise again the distance which we dropped in the last run, which is 4½ inches, and connecting the end of tee to the side of return pipe, thus completing a second circuit in the main lines. The main flow line is pitched down again from the last 4½-inch rise as indicated, making the last circuit on the extreme end of the system and gradually hitching back to the return connection of boiler. B represents the main return pipe in the system, and referring again to the pipe work on the left of boiler, the same general method is carried out, forming separate circuits according to the distance and conditions of the building, yet with only one flow and one return pipe connecting with the boiler. It is advisable to place air valves or air pipes at all high points on main flow lines, so that any air that might accumulate at such points, can be drawn or allowed to escape. This system of dividing the main flow line into various circuits gives a more uniform distribution of the hot water to the radiation, and allows the coldest water in the system to move back more rapidly to the boiler by not having to travel the entire distance of the flow line. In such pipe systems as that shown in plate H C the proportioning of the size of the pipes at the various points for the work to be performed is also an important matter, and long sweep fittings only should be used.

Greenhouse Heating.

A glass structure for horticultural purposes (owing to the manner of its construction and the materials employed) offers less resistance to the penetration of frost and cold winds than any other form of building, and necessarily requires a proportional greater amount of heat and its more even distribution.

33'-6"
Pitch 3"
25'-6"
Pitch 2"
Pitch 1"
12'-0"
4'-0"
Pitch 1/2"
18'-0"
Pitch 3/4"
16'-0"
Pitch 1 1/2"
Pitch 1/2"
6'-0"
Rise 4 1/2"
46'-0" Pitch 4 1/2"
Rise 6 3/4"
Pitch 1/2"
6'-0"
45'-0" Pitch 4"
18'-0" Pitch 1 1/4"
18'-0" Pitch 1 3/4"
Pitch 1 3/4"
17'-0"
9'-0"
Pitch 1/2
40'-0" Pitch 4"
46'-0" Pitch 4"
27'-0" Pitch 2 3/4"
18'-6"
Pitch 2"
7'-0"
Pitch 1/4
B
7'-0"
Pitch 1/2
A
Pitch 1/2"
40'-0" Pitch 4"
40'-0" Pitch 4"
To Return Opening
26'-0"
Pitch 2 1/2"
26'-0"
Pitch 2 1/2"
40'-9"
Pitch 4"
HEATER

PLATE H. C

To warm such a structure properly, without impairing the quality of the air, the heat must be produced by direct radiation from an extended surface heated to a moderate degree. The heating apparatus must be so arranged as to diffuse an even heat throughout every part of the house, and must be of sufficient heating power to increase the heat quickly in case of sudden changes in the weather, and to maintain the desired temperature during the nights, when the fires are unattended. Of the various systems that have been advanced to meet these requirements, there are but three that have met with approval in general use; these we name in their order of excellence. First in the order of efficiency and economy is the system of heating by the circulation of hot water through iron pipes ranged round the house; these pipes are connected to a boiler or water heater, which heats the water and maintains the circulation through the pipes; the radiation from the pipes supplies the warmth to the house. This is the best method known for the purpose; the facility with which water absorbs the heat produced at the boiler, and by circulation, rapidly conveys it to the most distant points in the line of heating pipes, renders it a most efficient agent, and affords the means of maintaining a uniform, even temperature of any required degree throughout all parts of the house; with a mild and humid atmosphere, which is congenial to the healthy growth and perfection of plants, flowers and fruit; while the substantial, enduring, and reliable qualities of the apparatus, the easy management and perfect control of heat in the house, or in several houses heated by the same fire the number of hours it may be left without attention, and the entire freedom from deleterious gases, dust and smoke, are among the advantages fairly claimed for the system.

It is so universal in its application, and offers so many advantages over every other system, that it is generally adopted, both here and in Europe, for heating plant houses of every size and description, from the small home conservatory to the largest botanical structures, and will be found in use, to the exclusion of all other methods, in the establishments of the most prominent and successful horticulturists throughout the country.

How to Figure Heating Surface of a Greenhouse.

In figuring a greenhouse we have to deal entirely with exposed surface, cubic contents, rarely, if ever, being taken into account; therefore, the entire amount of glass exposed and its equivalent should be determined, and in doing

this the ends and side walls should be figured just as surely as the overhead and end glass. The sides and end walls, if of wood, sheathed and papered good and tight, should be figured in the following proportions, viz.: Five square feet of wall to one square foot of glass.

After obtaining the number of square feet of glass and equivalent, the next point is the proper amount of heating surface necessary, and this is dependent upon the temperature required in the greenhouse. The following proportions of glass to heating surface will be found fairly accurate.

	St.	H. W.
To a temperature of 40 degrees, divide number of square feet of glass by	9	6
To a temperature of 45 degrees, divide number of square feet of glass by	8	5
To a temperature of 50 degrees, divide number of square feet of glass by	7	4
To a temperature of 55 degrees, divide number of square feet of glass by	6¼	3⅝
To a temperature of 60 degrees, divide number of square feet of glass by	6	3½
To a temperature of 65 degrees, divide number of square feet of glass by	5½	3¼
To a temperature of 70 degrees, divide number of square feet of glass by	5	3

The above is based on an outside temperature of zero.

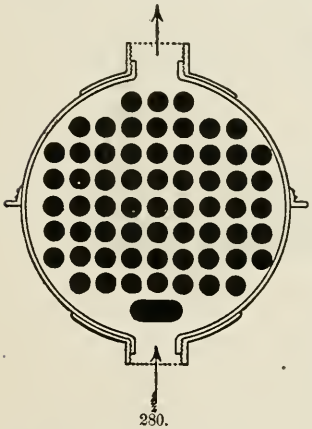
Hot Water Systems for Greenhouse Heating Under Pressure.

One of the special advantages in the pressure system is that a much greater range of temperature of water in the system can be had, and on this account, in cases of emergency, when a sudden fall in temperature must be guarded against, there will be no trouble to get the necessary heat. Another advantage possessed by the hot water system under pressure is, that any sized pipe can be used for mains and heating coils. For this system of heating wrought iron pipes are used with screw thread joints, and these are much less liable to leakage than cast iron calked joints. Then again, space is worth money in greenhouses, and heating coils of one-half the usual size that will do the same amount of heating, or more, are surely a great advantage.

With the open tank hot water system, it is not practical to carry the water higher than to a temperature of 200°, that is without pressure; but with the outlet from the expansion tank provided with a safety valve, the system may be run under any desired pressure, and in this way any desired temperature, even above 200°, can be had as readily as a temperature below 200°. To carry a hot water pressure of about fifty pounds per square inch in the heating apparatus we would have a temperature of the water in the system of 300°. It will, therefore, be seen that this is about double the temperature carried by

the old style, cast iron, open tank system, which runs about 150° on the average. However, it must be remembered that any style of boiler will not answer for a closed tank system, and consequently, in selecting a boiler for such work, this point should not be lost sight of.

For high pressure hot water heating, it will be necessary to have high pressure boilers, such as are tested to stand a hydraulic pressure of at least 200 pounds to the square inch, in order to be absolutely safe under any ordinary conditions. There are many types of hot water boilers in the market suitable for this class of work, which are not only built to resist any pressure that they may be called upon to withstand, but which are constructed to heat water rapidly and economically. One type of high pressure hot water boiler used largely in this country is the wrought iron tubular style, an end view of which is shown in the accompanying illustration, Fig. 280, and the special point of difference between this and the ordinary wrought iron, tubular steam boiler lies in the additional number of tubes in the former. This is done for the purpose of getting as much heating surface in the boiler as possible, and at the same time leaving ample space between the tubes for the proper and easy circulation of the water.



280.

Another special point to which I desire to call attention in this type of boiler is the tube connections. As will be noticed by referring to Fig. 281, the return connection is near the rear end at the bottom, while the flow or outlet connection from the boiler is on the top, near the front end of the boiler. This is a very good and important point in a hot water boiler, but not so much so in steam boilers. With the pipe connections arranged as shown in Fig. 281, the water must move through the greatest distance of the boiler, rising from bottom to top and passing from one end to the other, also entering at the coldest point and leaving the boiler from the hottest, directly over the fire in front. This disposition of the connections produces the most rapid circulation of the water through the system, which always means economy in fuel. To produce

the best circulation we must have the greatest possible difference in temperature between the return water entering the bottom of the boiler and the flow water leaving it at the top. These are some of the important things to know for those interested in hot water heating; it makes a vast difference how each part of a boiler is constructed.

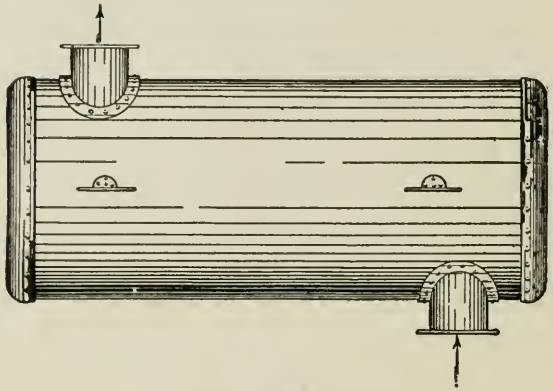


Fig. 281.

Hot Water Heating Without Boiler Pit.

It is a general supposition among florists, and also many practical hot water fitters, that to have a successful hot water heating plant for greenhouse work the boiler must be located in a pit or cellar several feet below the heating coils. Such, however, is not the case, but at the same time a more rapid circulation of water through the heating system will be found in plants where the boilers are located below the level of the greenhouse floor. There are many locations in which it is not practicable to build a boiler pit on account of low, wet ground. It is also a considerable item of expense to build a good boiler pit even on dry ground, especially if the site is a rocky one. Therefore under such circumstances the hot water boiler may be located, as shown in the accompanying illustration, Fig. 282, on a level with the greenhouse floor.

A partition, it will be noticed, divides the boiler shed and the greenhouse proper, so that, coal-gas, dust, and smoke which may escape from the fire will be excluded from the latter. As gravitation alone is the motive power for the circulation of water through hot water plants of this kind, the one essential

thing necessary will be to carry the pipes in such a manner that there will be a difference in temperature between the rising and falling columns of water. The best plan to obtain the greatest difference in temperature between these columns of water and secure the greatest motive power for circulation, is to carry all the hot water from the top of the boiler to as high a point as the building will permit of the delivery of this water into an expansion tank, as shown at T in the illustration. This flow pipe from the top of the boiler to the expansion tank should be covered with a good non-conducting pipe covering in order that no heat may escape until it enters the expansion tank. The

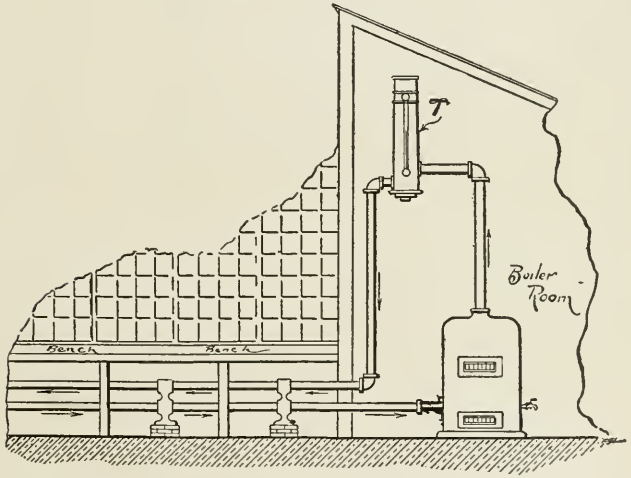


FIG. 282.

water is then carried from the tank at a point lower than the inlet as shown, connecting with the upper part of the bench coil and returning to bottom of the boiler as indicated by the direction of the arrows. The vertical line of supply pipe from the bottom of the expansion tank should not be covered, but allowed to act as heating surface, and in some places this pipe may be situated partly in the greenhouse, passing through the boiler room partition at a point just below the greenhouse roof. When expansion tanks are located at a high elevation, as shown in the accompanying illustration, it will be found convenient to have them provided with glass water gauges, so that the height of

water in the tank can be seen at a glance. Again, to fill heating plants of this kind a hose may be attached to the draw-off cock at the bottom of the boiler, when the water system is in or connected with the building. In work of this kind where four-inch cast iron pipes are used with hub joints, cast iron expansion tanks will be necessary; and as they are quite heavy, it will be necessary to provide a substantial support for the tank.

It is also an important matter to have solid foundations for the boiler and all the pillars on which the pipes rest, because they are comparatively heavy without water, and when filled with water, as they are when in operation, the combined weight will be considerable. Two good reasons for having solid supports for hot water greenhouse heating plants are: First, because east iron pipe of the size used on such work has very little flexibility to it, and will therefore break before it bends when improperly supported; and secondly, as it is also important to have hot water coils properly lined and pitched, for the purpose of getting a good and positive circulation of the water; a sag in the pipes will retard the flow of water and often stop circulation entirely.

Connecting Two or More Hot Water Boilers Together.

It not infrequently happens that we find it desirable to place in one building two or more boilers coupled together for warming purposes, and, in fact, for large buildings this plan is, without doubt, the best arrangement of the heating apparatus. For the reason that, in mild weather, the full capacity of of the apparatus is not required, and although it is possible to carry a slow fire at such times in a large boiler, it is much less trouble to handle a smaller size boiler and fire at a higher degree of heat. Other advantages in having more than one boiler are that in case some part of the boiler giving out in cold weather, and which might require some time to repair, in the case of having two one could be run alone until such times as the damage may be repaired without having to suffer to any great extent from cold. And, again, even without any damage to the boiler, it should be thoroughly cleaned from time to time during the winter season. This cannot be properly done unless the boiler is allowed to cool, and with a single boiler in a building with no other means of heat, it is not likely that the fire will be allowed to go out, unless by neglect, and consequently, the result is not only a great waste of fuel, but unsatisfactory work from the boiler, and much more wear to all parts of it. As I have many times said, the more clean we keep a machine of any kind, the

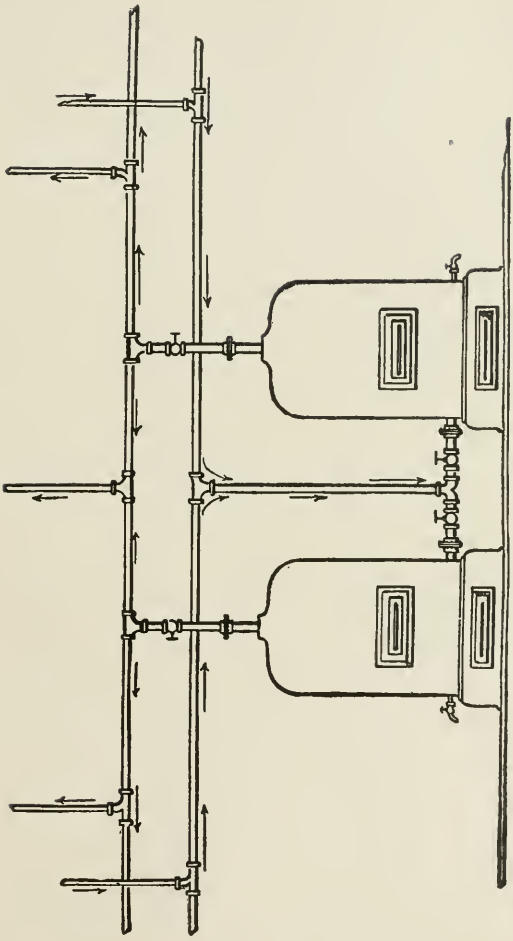


FIG. 283.

longer it will last. This holds good, especially in a house heating boiler. With two or more boilers coupled in the same plant, it will be quite possible to keep them clean, and at the same time keep the building warm. In connecting two hot water boilers together, there are some special points which the fitter or engineer must carefully consider, and while he must not lose sight of constructing a job that will operate to perfection, he has also a proper right to carefully consider how he can do the work with the least time and material. There are also disadvantages with two boilers, and one is, that it makes it necessary to use valves on the main floor and return pipes.

And as such pipes at the boilers are as a rule large size, the natural consequence will be considerable expense for those valves. There must also be proper provision made to entirely disconnect one boiler from the other, and that means large sized flange unions or other special fittings, as shown in the accompanying illustration. But there is still another point to be considered with the two-boiler system to which I desire to call attention, and that is the danger of starting up one of the boilers, that is, starting the fire and neglecting beforehand to open the valves. It is not necessary to state what the result would be in such a case. This has often happened to the knowledge of the writer, and in every case the result was a total wreck of the boiler.

To guard against such a possibility should be the aim of the fitter, and one good way is to use stop and waste valves on such work, on the same order as that used in plumbing work, so that when the valve is closed on the outside from the boiler, the closing operation will open a vent-hole to the atmosphere on the boiler side of the same valve.

This will allow any pressure formed in the boiler to escape, with the valves to flow and return pipes closed, and therefore relieve the boiler from over strain. By referring to the illustration, Fig. 283, it will be noticed that the flange unions are placed close to each boiler on the returns; this is so that the boiler on either side can be removed without, in any way affecting the other, and as will be noticed, the top or flow connections are made in the same manner. In large buildings heated by the hot water system, nothing but special large sweep hot water fittings should be allowed; such fittings are shown in the illustration, and are made by a number of manufacturers throughout the United States.

AREA OF CIRCLES, FROM $\frac{1}{64}$ TO 26 INCHES.

ADVANCING BY AN EIGHTH.

Diam.	Area.	Diam.	Area.	Diam.	Area.	Diam.	Area.
$\frac{1}{64}$	.000192	$\frac{3}{4}$	25.9673	$\frac{1}{8}$	125.185	$\frac{3}{8}$	294.832
$\frac{1}{32}$	.000767	$\frac{7}{8}$	27.1086	$\frac{1}{4}$	127.677	$\frac{1}{2}$	298.648
$\frac{1}{16}$	.003068	6.	28.2744	$\frac{3}{8}$	130.192	$\frac{5}{8}$	302.489
$\frac{1}{8}$	.012272	$\frac{1}{8}$	29.4648	13.	132.733	$\frac{3}{4}$	306.355
$\frac{3}{16}$	.027612	$\frac{1}{4}$	30.6797	$\frac{1}{8}$	135.297	$\frac{7}{8}$	310.245
$\frac{1}{4}$	.049087	$\frac{3}{8}$	31.9191	$\frac{1}{4}$	137.887	20.	314.16
$\frac{5}{16}$	.076699	$\frac{1}{2}$	33.1831	$\frac{3}{8}$	140.501	$\frac{1}{8}$	318.099
$\frac{3}{8}$	.110447	$\frac{5}{8}$	34.4717	$\frac{1}{2}$	143.139	$\frac{1}{4}$	322.063
$\frac{7}{16}$	.15033	$\frac{3}{4}$	35.7848	$\frac{5}{8}$	145.802	$\frac{3}{8}$	326.051
$\frac{1}{2}$	.19635	$\frac{7}{8}$	37.1224	$\frac{3}{4}$	148.49	$\frac{1}{2}$	330.064
$\frac{9}{16}$	.248505	7.	38.4846	$\frac{7}{8}$	151.202	$\frac{5}{8}$	334.102
$\frac{5}{8}$	.306796	$\frac{1}{8}$	39.8713	14.	153.938	$\frac{3}{4}$	338.164
$\frac{11}{16}$	.371224	$\frac{1}{4}$	41.2826	$\frac{1}{8}$	156.7	$\frac{7}{8}$	342.25
$\frac{3}{4}$	.441787	$\frac{3}{8}$	42.7184	$\frac{1}{4}$	159.485	21.	346.361
$\frac{13}{16}$	.518487	$\frac{1}{2}$	44.1787	$\frac{3}{8}$	162.296	$\frac{1}{8}$	350.497
$\frac{7}{8}$	.601322	$\frac{5}{8}$	45.6636	$\frac{1}{2}$	165.13	$\frac{1}{4}$	354.657
$\frac{15}{16}$	.690292	$\frac{3}{4}$	47.1731	$\frac{5}{8}$	167.99	$\frac{3}{8}$	358.842
1.	.7854	$\frac{7}{8}$	48.7071	$\frac{3}{4}$	170.874	$\frac{1}{2}$	363.051
$\frac{1}{8}$	.99402	8.	50.2656	$\frac{7}{8}$	173.782	$\frac{5}{8}$	367.285
$\frac{1}{4}$	1.2272	$\frac{1}{8}$	51.8487	15.	176.715	$\frac{3}{4}$	371.543
$\frac{3}{8}$	1.4849	$\frac{1}{4}$	53.4563	$\frac{1}{8}$	178.673	$\frac{7}{8}$	375.826
$\frac{1}{2}$	1.7671	$\frac{3}{8}$	55.0884	$\frac{1}{4}$	182.655	22.	380.134
$\frac{5}{8}$	2.0739	$\frac{1}{2}$	56.7451	$\frac{3}{8}$	185.661	$\frac{1}{8}$	384.466
$\frac{3}{4}$	2.4053	$\frac{5}{8}$	58.4264	$\frac{1}{2}$	188.692	$\frac{1}{4}$	388.822
$\frac{7}{8}$	2.7612	$\frac{3}{4}$	60.1322	$\frac{5}{8}$	191.748	$\frac{3}{8}$	393.303
2.	3.1416	$\frac{7}{8}$	61.8625	$\frac{3}{4}$	194.828	$\frac{1}{2}$	397.609
$\frac{1}{8}$	3.5466	9.	63.6174	$\frac{7}{8}$	197.933	$\frac{5}{8}$	402.038
$\frac{1}{4}$	3.9761	$\frac{1}{8}$	65.3968	16.	201.062	$\frac{3}{4}$	406.494
$\frac{3}{8}$	4.4301	$\frac{1}{4}$	67.2008	$\frac{1}{8}$	204.216	$\frac{7}{8}$	410.973
$\frac{1}{2}$	4.9087	$\frac{3}{8}$	69.0293	$\frac{1}{4}$	207.395	23.	415.477
$\frac{5}{8}$	5.4119	$\frac{1}{2}$	70.8823	$\frac{3}{8}$	210.598	$\frac{1}{8}$	420.004
$\frac{3}{4}$	5.9396	$\frac{5}{8}$	72.7599	$\frac{1}{2}$	213.825	$\frac{1}{4}$	424.558
$\frac{7}{8}$	6.4918	$\frac{3}{4}$	74.6621	$\frac{5}{8}$	217.077	$\frac{3}{8}$	429.135
3.	7.0686	$\frac{7}{8}$	76.5888	$\frac{3}{4}$	220.354	$\frac{1}{2}$	433.737
$\frac{1}{8}$	7.6699	10.	78.54	$\frac{7}{8}$	223.655	$\frac{5}{8}$	438.364
$\frac{1}{4}$	8.2958	$\frac{1}{8}$	80.5158	17.	226.981	$\frac{3}{4}$	443.015
$\frac{3}{8}$	8.9462	$\frac{1}{4}$	82.5161	$\frac{1}{8}$	230.331	$\frac{7}{8}$	447.69
$\frac{1}{2}$	9.6211	$\frac{3}{8}$	84.5409	$\frac{1}{4}$	233.706	24.	452.39
$\frac{5}{8}$	10.3206	$\frac{1}{2}$	86.5903	$\frac{3}{8}$	237.105	$\frac{1}{8}$	457.115
$\frac{3}{4}$	11.0447	$\frac{5}{8}$	88.6643	$\frac{1}{2}$	240.529	$\frac{1}{4}$	461.864
$\frac{7}{8}$	11.7933	$\frac{3}{4}$	90.7628	$\frac{5}{8}$	243.977	$\frac{3}{8}$	466.638
4.	12.5664	$\frac{7}{8}$	92.8858	$\frac{3}{4}$	247.45	$\frac{1}{2}$	471.436
$\frac{1}{8}$	13.3641	11.	95.0334	$\frac{7}{8}$	250.948	$\frac{5}{8}$	476.259
$\frac{1}{4}$	14.1863	$\frac{1}{8}$	97.2055	18.	254.47	$\frac{3}{4}$	481.107
$\frac{3}{8}$	15.033	$\frac{1}{4}$	99.4022	$\frac{1}{8}$	258.016	$\frac{7}{8}$	485.979
$\frac{1}{2}$	15.9043	$\frac{3}{8}$	101.6234	$\frac{1}{4}$	261.587	25.	490.875
$\frac{5}{8}$	16.8002	$\frac{1}{2}$	103.8691	$\frac{3}{8}$	265.183	$\frac{1}{8}$	495.796
$\frac{3}{4}$	17.7206	$\frac{5}{8}$	106.1394	$\frac{1}{2}$	268.803	$\frac{1}{4}$	500.742
$\frac{7}{8}$	18.6655	$\frac{3}{4}$	108.4343	$\frac{5}{8}$	272.448	$\frac{3}{8}$	505.712
5.	19.635	$\frac{7}{8}$	110.7537	$\frac{3}{4}$	276.117	$\frac{1}{2}$	510.706
$\frac{1}{8}$	20.629	12.	113.098	$\frac{7}{8}$	279.811	$\frac{5}{8}$	515.726
$\frac{1}{4}$	21.6476	$\frac{1}{8}$	115.466	19.	283.529	$\frac{3}{4}$	520.769
$\frac{3}{8}$	22.6907	$\frac{1}{4}$	117.859	$\frac{1}{8}$	287.272	$\frac{7}{8}$	525.838
$\frac{1}{2}$	23.7583	$\frac{3}{8}$	120.277	$\frac{1}{4}$	291.04	26.	530.93
$\frac{5}{8}$	24.8505	$\frac{1}{2}$	122.719				

NOTE.—The area of a circle is its diameter squared multiplied by 0.7854.
The circumference of a circle is its diameter multiplied by 3.1416.

Heat.

The quality or intensity of heat is measured or indicated by a thermometer. There are three different forms of thermometers in use, viz., The Fahrenheit, used in this country and in Great Britain, where 32° denotes the temperature of freezing water, and 212° denotes that of water boiling in an open vessel at the sea level; the Centigrade thermometer (used in France), where 0° denotes freezing water and 100° the temperature of boiling water; and the Reaumur thermometer, used in Germany, in which 0° and 80° respectively denotes these water conditions.

If the Fahr. temperature is reduced by 32,° $\frac{5}{9}$ of the remainder is the corresponding Centigrade temperature. If the Fahr. temperature is reduced by 32°, $\frac{4}{9}$ of the remainder is the Reaumur temperature.

The quantity of heat is measured in heat units. The quantity of heat required to raise one pound avoirdupois of water one degree Fahr. in temperature is called a heat unit.

Sensible heat is apparent to a thermometer.

Latent heat is not apparent to or directly measured by a thermometer. Latent heat is dormant, inactive, potential.

Thus, if a pound of ice at 32° Fahr. is melted, to form water at 32° Fahr., 142 heat units must be given by some other body, say the air. These 142 heat units are called "the latent heat of ice" and must be expended to change the solid ice into a liquid—water. While this change is taking place no effect is visible on the thermometer placed in the ice, or in its resulting pound of water. This energy is employed in doing internal work on the ice, and has now become latent in the water. If the pound of water were frozen to ice again the 142 units become liberated and active.

As the one pound of water at 32° F. becomes heated, its temperature rises until it finally assumes say 212° F. A thermometer shows that its temperature has now increased 180° F.; and it follows that 180 heat units have been given to the water.

If the pound of water at 212° is in an open vessel at the sea level, and further heat be applied, the temperature does not rise, but the liquid becomes a gas, or steam, at 212° F. To change a pound of water at 212° F. into steam at 212° F. requires an expenditure of 966 heat units. Hence the 966 units thus used are not apparent to a thermometer—but are latent or potential in the steam, and have been required to do internal work upon the particles of the

pound of mobile liquid, changing them into a repellant gas or steam, of one pound's weight. The 966 units denote the latent heat of steam at atmospheric pressure.

Different bodies require different amounts of heat to raise their temperature one degree Fahr., per pound. This is shown in the following table:

TABLE OF SPECIFIC HEATS.

Water,	1.0000	Silver,	0.0570
Molten Lead,	0.0402	Tin,	0.0570
" Sulphur,	0.2340	Steel,	0.1170
" Bismuth,	0.0308	Zinc,	0.0956
" Tin,	0.0637	Brass,	0.0939
Sulphuric Acid,	0.3350	Ice,	0.5040
Mercury,	0.0333	Charcoal,	0.2410
Alcohol,	0.7000	Sulphur,	0.2026
Benzine,	0.4500	Alumina,	0.1970
Antimony,	0.0508	Phosphorus,	0.1887
Copper,	0.0951		
Gold.	0.0324	(UNDER A CONSTANT PRESSURE.)	
Wrought Iron,	0.1138	Air,	0.2375
Glass,	0.1937	Oxygen,	0.2175
Cast Iron,	0.1298	Hydrogen,	3.4090
Lead,	0.0314	Nitrogen,	0.2438
Platinum,	0.0324	Superheated Steam,	0.4805

The Table shows that a heat unit will raise a pound of water 1° F. in temperature; a pound of mercury, 30° F.; a pound of ice, 2° F.; a pound of hydrogen less then $\frac{1}{3}$ of a degree F.; a pound of steam over two degrees; or a pound of air over 4° F.

The heat required to raise one pound of a substance one degree F. is called specific heat, so that the specific heat of water is one, silver 0.0570, air 0.2375, steam 0.4805, etc., as shown in the table.

Heat is communicated only from a hotter to a colder body. It is transmitted by either conduction, convection or radiation. Conduction denotes the transit of heat from particle to particle of a body. Thus one end of a poker held in the fire becomes heated, and conducts its heat to the hand. Convection of heat takes place by currents of air or water moving along a hot body. Thus the air at a radiator becomes heated, and, rising, forms a convection current, and colder air replaces it, only to itself become heated and rise. Radiation of heat is in straight lines, as from a hot radiator to a person sitting alongside.

If the conducting power of silver be called one, that of other substances is shown by the following:

Silver	1.000
Gold	.981
Copper	.845
Mercury	.677
Steel	.397
Lead	.287

The poor conducting powers of air, hair, magnesia, asbestos, etc., are taken advantage of in protecting steam pipes from radiating their heat, and in protecting water pipes in cold climates. Water has very little conducting, but great convecting capacity.

THERMOMETER SCALES.

n Degrees Celsius = 32 + $\frac{9}{5}$ n ° Fahr. = $\frac{4}{5}$ n ° Réau.
n Degrees Réaumur = 32 + $\frac{9}{4}$ n ° Fahr. = $\frac{5}{4}$ n ° Cels.
n Degrees Fahrenheit = $\frac{5}{9}$ (n — 32) ° Cels. = $\frac{4}{9}$ (n — 32) ° Réau.

TABLE.

Cels.	Fahr.	Reau.	Cels.	Fahr.	Réau.	Cels.	Fahr.	Réau.	Cels.	Fahr.	Réau.
—40	—40	—32	6	42,8	4,8	52	125,6	41,6	98	208,4	78,4
—39	—38,2	—31,2	7	44,6	5,6	53	127,4	42,4	99	210,2	79,2
—38	—36,4	—30,4	8	46,4	6,4	54	129,2	43,2	100	212,0	80,0
—37	—34,6	—29,6	9	48,2	7,2	55	131,0	44,0	101	213,8	80,8
—36	—32,8	—28,8	10	50,0	8,0	56	132,8	44,8	102	215,6	81,6
—35	—31	—28	11	51,8	8,8	57	134,6	45,6	103	217,4	82,4
—34	—29,2	—27,2	12	53,6	9,6	58	136,4	46,4	104	219,2	83,2
—33	—27,4	—26,4	13	55,4	10,4	59	138,2	47,2	105	221,0	84,0
—32	—25,6	—25,6	14	57,2	11,2	60	140,0	48,0	106	222,8	84,8
—31	—23,8	—24,8	15	59,0	12,0	61	141,8	48,8	107	224,6	85,6
—30	—22	—24	16	60,8	12,8	62	143,6	49,6	108	226,4	86,4
—29	—20,2	—23,2	17	62,6	13,6	63	145,4	50,4	109	228,2	87,2
—28	—18,4	—22,4	18	64,4	14,4	64	147,2	51,2	110	230,0	88,0
—27	—16,6	—21,6	19	66,2	15,2	65	149,0	52,0	111	231,8	88,8
—26	—14,8	—20,8	20	68,0	16,0	66	150,8	52,8	112	233,6	89,6
—25	—13	—20	21	69,8	16,8	67	152,6	53,6	113	235,4	90,4
—24	—11,2	—19,2	22	71,6	17,6	68	154,4	54,4	114	237,2	91,2
—23	— 9,4	—18,4	23	73,4	18,4	69	156,2	55,2	115	239,0	92,0
—22	— 7,6	—17,6	24	75,2	19,2	70	158,0	56,0	116	240,8	92,8
—21	— 5,8	—16,8	25	77,0	20,0	71	159,8	56,8	117	242,6	93,6
—20	— 4	—16	26	78,8	20,8	72	161,6	57,6	118	244,4	94,4
—19	— 2,2	—15,2	27	80,6	21,6	73	163,4	58,4	119	246,2	95,2
—18	— 0,4	—14,4	28	82,4	22,4	74	165,2	59,2	120	248,0	96,0
—17	1,4	—13,6	29	84,2	23,2	75	167,0	60,0	121	249,8	96,8
—16	3,2	—12,8	30	86,0	24,0	76	168,8	60,8	122	251,6	97,6
—15	5,0	—12,0	31	87,8	24,8	77	170,6	61,6	123	253,4	98,4
—14	6,8	—11,2	32	89,6	25,6	78	172,4	62,4	124	255,2	99,2
—13	8,6	—10,4	33	91,4	26,4	79	174,2	63,2	125	257,0	100,0
—12	10,4	— 9,6	34	93,2	27,2	80	176,0	64,0	126	258,8	100,8
—11	12,2	— 8,8	35	95,0	28,0	81	177,8	64,8	127	260,6	101,6
—10	14,0	— 8,0	36	96,8	28,8	82	179,6	65,6	128	262,4	102,4
— 9	15,8	— 7,2	37	98,6	29,6	83	181,4	66,4	129	264,2	103,2
— 8	17,6	— 6,4	38	100,4	30,4	84	183,2	67,2	130	266,0	104,0
— 7	19,4	— 5,6	39	102,2	31,2	85	185,0	68,0	131	267,8	104,8
— 6	21,2	— 4,8	40	104,0	32,0	86	186,8	68,8	132	269,6	105,6
— 5	23,0	— 4,0	41	105,8	32,8	87	188,6	69,6	133	271,4	106,4
— 4	24,8	— 3,2	42	107,6	33,6	88	190,4	70,4	134	273,2	107,2
— 3	26,6	— 2,4	43	109,4	34,4	89	192,2	71,2	135	275,0	108,0
— 2	28,4	— 1,6	44	111,2	35,2	90	194,0	72,0	136	276,8	108,8
— 1	30,2	— 0,8	45	113,0	36,0	91	195,8	72,8	137	278,6	109,6
0	32,0	0	46	114,8	36,8	92	197,6	73,6	138	280,4	110,4
1	33,8	0,8	47	116,6	37,6	93	199,4	74,4	139	282,2	111,2
2	35,6	1,6	48	118,4	38,4	94	201,2	75,2	140	284,0	112,0
3	37,4	2,4	49	120,2	39,2	95	203,0	76,0	141	285,8	112,8
4	39,2	3,2	50	122,0	40,0	96	204,8	76,8	142	287,6	113,6
5	41,0	4,0	51	123,8	40,8	97	206,6	77,6	143	289,4	114,4

STEAM ESTIMATE BLANK.

NOTE.—This estimate is intended to give as near as possible the net cost of complete apparatus. The fitter is cautioned, however, to go over the same carefully and provide for any favorable or unfavorable local conditions, and make generous allowance for contingent expenses and profit.

No._____Steam Boiler,
Square Feet Direct Radiators,
Square Feet Indirect Radiators,
Pipe and Fittings,
Radiator Valves, Ceiling and Floor Plates,
Positive Air Cocks,
Automatic Air Cocks,
Automatic Water Feeder,
Smoke Pipe,
Day's Labor Piping (Man and Helper)
Bronzing and Painting (Labor and Material),
Day's Board,
Car Fare,
Freight,
Cartage,
Covering Pipe,
Carpenter Work,
Registers for Indirect,
Incidentals,

For_____ Net Cost,_____

_____ Profit,_____

_____ Bid,_____

Date_____ Submitted by_____

WATER ESTIMATE BLANK.

No._____Hot Water Heater,
Square Feet Direct Radiators,
Square Feet Indirect Radiators,
Pipe and Fittings,
Radiator Valves, Union Ells, Air Cocks, Floor and Ceiling Plates,
Draw-off Cock, Feed Cock,
Expansion Tank,
Damper Regulator,
Smoke Pipe,
Day's Labor Piping (Man and Helper),
Bronzing and Painting (Labor and Material),
Day's Board,
Car Fare,
Freight,
Cartage,
Covering Pipe,
Thermometer,
Altitude Gauge,
Automatic Air Valves,
Carpenter Work,
Registers for Indirect,
Incidentals,

For_____ Net Cost,_____

_____ Profit,_____

_____ Bid,_____

Date_____ Submitted by_____

Hartford Steam Boiler Inspection and Insurance Company's Rule for Ascertaining the Safe Working Pressure of a Cylindrical Boiler.

Multiply the tensile strength of the iron or steel, by the thickness of the plate. Then multiply this product by the efficiency of the joint, and divide the result by the radius or half diameter of the boiler. This gives the bursting pressure, and this result divided by the factor of safety gives the safe working pressure. The factor of safety generally adopted is 5.

The strength of a properly proportioned *single* riveted joint is 50 to 60% to the total strength of the plate. A properly proportioned *double* riveted joint 72 to 75%.

A properly proportioned *triple* riveted joint with inside and outside welt strips, 85 to 87½%. In this last joint the outside welt strip takes simply two rows of rivets, the inside strip being wide enough to take three rows; the pitch of the third row, however, is double that of the other rows.

This rule may be expressed as follows:

Safe working pressure =

$$\frac{\text{tensile strength} \times \text{thickness} \times \text{efficiency of joint}}{\text{radius} \times \text{factor of safety.}}$$

EXAMPLE.

What is the safe working pressure of a boiler 60 inches in diameter, constructed of steel: plates ⅜ inch thick, with tensile strength of 58,000 lbs. per square inch: longitudinal joint double riveted, having an efficiency of 70% of the solid plate: factor of safety 5?

$$\text{Safe pressure} = \frac{58{,}000 \times .375 \times .70}{30 \times 5} = 101.5 \text{ lbs.}$$

This rule assumes that the heads of the boiler are well braced. The strain or load on any one brace should not exceed 6,500 lbs. per square inch. If there are no welds in the braces 7,500 lbs. may be allowed.

The strength of a properly proportioned single riveted joint is 50 per cent. to 60 per cent. of the strength of the plate.

A properly proportioned double riveted joint 71 per cent. to 75 per cent.

A properly proportioned triple riveted joint, with inside and outside welt strips, 85 per cent. to 87½ per cent.

Mr. William G. Pike, Consulting Engineer of Hartford Insurance Co., Philadelphia, furnishes the following figures for boilers of different dimensions, showing the pressures they will carry:

	Diameter of Boiler, 60 Steam Pressure Allowed, 130 lbs	Diameter of Boiler, 66 Steam Pressure Allowed, 125 lbs	Diameter of Boiler, 66 Steam Pressure Allowed, 130 lbs	Diameter of Boiler, 72 Steam Pressure Allowed, 130 lbs	Diameter of Boiler, 72 Steam Pressure Allowed, 135 lbs
Distance A	1¾	1¾	1¾	1 13/16	1 13/16
Distance B	2 3/16	2 3/16	2 3/16	2¼	2¼
Distance C	2 11/16	2 11/16	2 11/16	2¾	2¾
Distance D	7	7	7	7	7⅛
Distance E	3½	3½	3½	3⅝	3⅝
Distance F	⅞	⅞	⅞	15/16	15/16
Diameter Rivets	¾	¾	13/16	⅞	⅞
Diameter Rivet Holes	13/16	13/16	⅞	15/16	15/16
Thickness Shell Plates	½	½	9/16	5/8	11/16
Thickness Welt Strips	½	½	½	½	½

Factor of safety is 5 in all the above. Tensile strength is figured at 55,000 lbs. according to the uniform custom of the Hartford Insurance Co.

CAST-IRON WATER PIPE.

STANDARD WEIGHT.

Size	2	3	4	6	8	10	12	14	16	18	20	24	30	36
Approximate thickness	5/16	7/16	1 9/32	1/2	1/2	17/32	9/16	11/16	3/4	27/32	27/32	1 1/8	1 1/4	1 1/4
Approximate weight per ft.	7	15	22	33	42	60	75	105	130	167	180	240	358	480

Tested to 300 lbs., Hydrostatic pressure, and coated inside and out. 2 inch in 9 ft. lengths ; other sizes in 12 ft. lengths.

CAST-IRON GAS PIPE.

STANDARD WEIGHT.

Size	2	3	4	6	8	10	12	14	16	18	20	24	30	36
Thickness	5/16	11/32	7/16	7/16	7/16	1/2	9/16	9/16	9/16	5/8	5/8	11/16	7/8	1
Approximate weight per ft.	6	12 1/2	17	28	38	54	70	85	110	134	140	180	255	325

Tested to 250 lbs., Hydrostatic pressure, not coated. 2 in. in 9 ft. lengths; other sizes in 12 ft lengths.

TABLE OF LEAD AND HEMP REQUIRED TO PROPERLY CALK THE JOINTS OF DIFFERENT SIZES OF CAST-IRON PIPES.

Size	2	3	4	6	8	10	12	14	16	18	20	24	30	36
Lead per joint, pounds	1 1/4	4	5 1/2	8	11	15	18	22	24	26	28	32	38	50
Hemp per joint, ounces	2	6	7	9	11	13	18	20	22	24	28	32	38	44

LIST AND NOMINAL WEIGHTS OF REGULAR CAST-IRON PIPE FITTINGS.

CROSSES.

Size.	Weight.	Size.	Weight.
3x 3x 3x 3	84	10x10x 4x 4	375
4x 4x 4x 4	152	12x12x12x12	890
6x 6x 6x 6	360	12x12x10x10	690
6x 6x 4x 4	210	12x12x 8x 8	600
8x 8x 8x 8	390	12x12x 6x 6	580
8x 8x 6x 6	355	12x12x 4x 4	480
8x 8x 4x 4	265	16x16x16x16	1380
10x10x10x10	525	20x20x20x20	1875
10x10x 8x 8	520	24x24x24x24	2300
10x10x 6x 6	450		

ELBOWS.

Size.	Weight.	Size.	Weight.
3	44	12	412
4	90	16	740
6	178	20	1218
8	195	24	2000
10	315	39	2500

PLUGS.

Size.	Weight.	Size.	Weight.
3	4	10	40
4	7	12	71
6	15	16	100
8	22		

SLEEVES.

Size.	Weight.	Size.	Weight.
3	28	16	305
4	36	20	385
6	65	24	525
8	110	30	775
10	155	36	1000
12	190		

TEES.

Size.	Weight.	Size.	Weight.
3x 3x 3	65	10x10x 4	300
4x 4x 4	115	12x12x12	635
6x 6x 6	150	12x12x10	461
6x 6x 4	185	12x12x 8	455
8x 8x 8	290	12x12x 6	460
8x 8x 6	260	12x12x 4	450
8x 8x 4	260	16x16x16	1000
10x10x10	450	20x20x20	1440
10x10x 8	440	24x24x24	1875
10x10x 6	382		

REDUCERS.

Bell large end always sent unless specially ordered with bell on small end.

Size.	Weight.	Size.	Weight.
4x3	55	10x 4	180
6x4	105	12x10	345
8x6	170	12x 8	240
8x4	115	12x 6	200
10x8	220	16x12	375
10x6	150	24x20	914

45° ELBOWS.

Size.	Weight.	Size.	Weight.
3	38	12	325
4	72	16	560
6	112	20	1170
8	250	24	1450
10	270	30	2200

Y BRANCHES.

All sizes from ..... 4 to 36 inches.

SPLIT SLEEVES.

All sizes from..... 4 to 24 inches.

WEIGHT OF FLAT IRON PER LINEAL FOOT.

Size	⅛	¼	5/16	⅜	7/16	½	⅝	¾	⅞	1	1¼	1½
½	.211	.422	.528	.634	.738	.845	1.056	1.265	1.477	1.690	2.112	2.535
⅝	.264	.528	.660	.792	.923	1.056	1.320	1.584	1.846	2.112	2.640	3.168
¾	.316	.633	.792	.950	1.108	1.265	1.584	1.901	2.217	2.534	3.168	3.802
⅞	.369	.738	.923	1.108	1.294	1.477	1.846	2.217	2.588	2.956	3.696	4.435
1	.422	.845	1.056	1.267	1.478	1.690	2.112	2.534	2.956	3.380	4.224	5.069
1⅛	.475	.950	1.187	1.425	1.663	1.901	2.375	2.850	3.326	3.802	4.752	5.703
1¼	.528	1 056	1.320	1.584	1.848	2.112	2.640	3.168	3 696	4.224	5.280	6.337
1⅜	.580	1.161	1.452	1.742	2.032	2.325	2 904	3.484	4.065	4.646	5.808	6.970
1½	.633	1.266	1.584	1.900	2.217	2.535	3.168	3.802	4.435	5.069	6.337	7.604
1⅝	.686	1.372	1.716	2.059	2.402	2.746	3.432	4.119	4.805	5.492	6.864	8.237
1¾	.739	1.479	1.848	2.218	2.589	2.957	3.696	4.435	5.178	5.914	7.393	8.871
1⅞	.792	1.584	1.980	2.376	2.772	3.168	3.960	4.752	5.544	6.336	7.921	9.505
2	.845	1.689	2.112	2.534	2.957	3.379	4.224	5.069	5.914	6.758	8.448	10.138
2⅛	.898	1.795	2.244	2.693	3.141	3.591	4.488	5.386	6.283	7.181	8.977	10.772
2¼	.950	1.900	2.376	2.851	3.326	3.802	4.752	5.703	6.653	7.604	9.505	11.406
2⅜	1.003	2.006	2.508	3.009	3.511	4.013	5.016	6.019	7.022	8.025	10.032	12.038
2½	1.056	2.112	2.640	3.168	3.696	4.224	5.280	6.336	7.392	8.448	10.560	12.672
2⅝	1.109	2.218	2.772	3.327	3.879	4.436	5.545	6.654	7.763	8.872	11.090	13.308
2¾	1.162	2.323	2.904	3 485	4.066	4.647	5.808	6.970	8.132	9.294	11.617	13.940
2⅞	1.215	2.429	3.036	3.644	4.249	4.858	6.072	7.287	8.502	9.716	12.145	14.574
3	1.267	2.535	3.168	3.802	4.435	5.069	6.337	7.604	8.871	10.138	12.673	15.208
3⅛	1.373	2.746	3.432	4.119	4.805	5.492	6.865	8.237	9.610	10.983	13.730	16.475
3¼	1.479	2.957	3.696	4.436	5.175	5.914	7.393	8.871	10.350	11.828	14.785	17.742
3⅜	1.584	3 168	3.960	4.752	5.544	6.336	7.921	9.505	11.089	12.673	15.841	19.009
4	1.690	3.380	4.224	5 069	5.914	6.759	8.448	10.138	11.828	13.518	16.897	20.277
4¼	1.795	3.591	4.488	5.386	6.282	7.181	8.977	10.772	12.566	14.364	17.953	21.544
4½	1.900	3.802	4.752	5.703	6.653	7.604	9.504	11.406	12.306	15.208	19.010	22.812
4¾	2.016	4.013	5.016	6.020	7.020	8.026	10.033	12.039	14.043	16.052	20.060	24.079
5	2.111	4.224	5.280	6.336	7.392	8.449	10.560	12.673	14.784	16.897	21.122	25.346
5¼	2.206	4.436	5.544	6.651	7.758	8.871	11.089	13 307	15.520	17.742	22.178	26.613
5½	2.322	4.647	5.803	6.970	8.132	9.294	11.616	13.940	16.264	18.587	23.234	27.881
5¾	2.428	4.858	6.072	7.288	8.496	9.716	12.145	14.574	16.997	19.432	24.290	29.148
6	2.533	5.070	6.337	7.604	8.871	10.138	12.674	15.208	17.742	20.276	25.346	30.416

Weight of Copper and Brass Wire and Plates.

WEIGHT OF COPPER AND BRASS WIRE.
Diameters determined by American Gauge.

No. of Gauge.	Size of each No.	Weight of Wire per 1000 Lineal Ft.			
		Wro't Iron.	Steel.	Copper.	Brass.
	Inch.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
0000	.46000	560.74	566.03	640.51	605.18
000	.40964	444.68	448.88	507.95	479.91
00	.36480	352.66	355.99	402.83	380 67
0	.32486	279.67	282.30	319.45	301.82
1	.28930	221.79	223.89	253.34	239.35
2	.25763	175.89	177.55	200.91	189.82
3	.22942	139.48	140.80	159 32	150 52
4	.20431	110.62	111.66	126.35	119.38
5	18194	877.20	88.548	100.20	94.666
6	.16202	69.565	70.221	79.462	75.075
7	.14428	55.165	55.685	63.013	59.545
8	.12849	43.751	44.164	49.976	47.219
9	.11443	34 699	35.026	39.636	37.437
10	.10189	27.512	27.772	31.426	29.687
11	.090742	21.820	22.026	24.924	23 549
12	.080808	17.304	17.468	19.766	18.676
13	.071961	13.722	13.851	15.674	14.809
14	.064084	10.886	10 989	12.435	11.746
15	.057068	8.631	8.712	9.859	9.315
16	.050820	6.845	6.909	7.819	7.587
17	.045257	5.427	5.478	6.199	5.857
18	.040303	3.304	4.344	4.916	4 645
19	.035890	3.413	3.445	3.899	3.684
20	.031961	2.708	2.734	3 094	2.920
21	.028462	2.147	2.167	2.452	2.317
22	.025347	1.703	1.719	1.945	1.838
23	.022571	1.350	1.363	1.542	1.457
24	.020100	1 071	1.081	1.223	1.155
25	.017900	0.8491	0.8571	.9699	0.9163
26	.01594	0.6734	0.6797	.7692	0.7267
27	.014195	0.5340	0.5391	.6099	0.5763
28	.012641	0.4235	0.4275	.4837	0.4570
29	.011257	0.3358	0.3389	.3835	0.3624
30	.010025	0.2663	0.2688	.3042	0.2874
31	.008928	0.2113	0.2132	.2413	0.2280
32	.007950	0.1675	0.1691	.1913	.1808
33	.007080	0.1328	0.1341	.1517	.1434
34	.006304	0.1053	0.1063	.1204	.1137
35	.005614	08366	.08445	.0956	0.9015
36	.005000	.06625	.06687	.0757	0715
37	.004453	.05255	.05304	.06003	05671
38	.003965	.04166	04205	.04758	.04496
39	.003531	.03305	03336	.03755	.03566
40	.003144	.02620	.02649	.02992	.02827
Specific Gravity..		7.7747	7.848	8.880	8.386
Weight per Cubic Foot.....		485.874	90.45	554 988	524.16

WEIGHT OF COPPER AND BRASS PLATES.
Thickness determined by American Gauge.

Weight of Plates per Square Foot.			
Wro't Iron.	Steel.	Copper.	Brass.
Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
17.25	17.48	20.838	19.688
15.3615	15.5663	18.557	17.533
13.68	13.8624	16.525	15.613
12.1823	13.3447	14.716	13.904
10.8488	10.9934	13.105	12.382
9.6611	9.7890	11.671	11.027
8.6033	8.7180	10.393	9.8192
7.6616	7.7638	9.2552	8.7445
6.8228	6.9137	8.2419	7.787
6.0758	6.1568	7.3395	6.9345
5.4105	5.4826	6 5359	6.1752
4.8184	4.8826	5.8206	5.4994
4.2911	4.3483	5.1837	4.8976
3.8209	3.8718	4.6156	4.3609
3.4028	3.4482	4.1106	3.8838
3.0303	3.0707	3.6606	3.4586
2.6985	2.7345	3.2598	3.0799
2.4032	2.4352	2.9030	2.7428
2.1401	2.1686	2.5852	2.4425
1.9058	1.9312	2.3021	2.1751
1.6971	1 7198	2.0501	1.937
1.5114	1.5315	1.8257	1.725
1.3459	1.3638	1.6258	1.5361
1.1985	1.2145	1.4478	1.3679
1 0673	1.0816	1.2893	1.2182
.95051	.96319	1.1482	1.0849
.84641	.8577	1.0225	.96604
.75375	.7638	.91053	.86028
.67125	.6802	.81087	.76612
.59775	.60572	72208	.68223
.53231	.53941	.64303	.60755
.47404	.48036	.57264	.54103
.42214	.42777	.50994	.48180
.37594	.38095	.45413	.42907
.3348	.33926	.40444	.38212
.29813	.3021	36014	.34026
.2655	.26904	.32072	.30302
.2364	.23955	.28557	.26981
.21053	.21333	.25431	.24028
.1875	.19	.2265	.2140
.16699	.16921	.20172	.19059
.14869	.15067	.17961	.1697
.13241	.13418	.15995	.15113
.1179	.11947	.14242	.13456
7.200	7.296	8.698	8.218
450	456.	543.6	513.6

TABLE SHOWING FRACTIONS OF AN INCH REDUCED TO DECIMAL EQUIVALENT.

1 64	Equals	.015625
1 32	"	.031250
3 64	"	.046875
1 16	"	.062500
5 64	"	.078125
3 32	"	.093750
7 64	"	.109375
1 8	"	.125000
9 64	"	.140625
5 32	"	.156250
11 64	"	.171875
3 16	"	.187500
13 64	"	.203125
7 32	"	.218750
15 64	"	.234375
1 4	"	.250000
17 64	"	.265625
9 32	"	.281250
19 64	"	.296875
5 16	"	.312500
21 64	"	.328125
11 32	"	.343750
23 64	"	.359375
3 8	"	.375000
25 64	"	.390625
13 32	"	.406250
27 64	"	.421875
7 16	"	.437560
29 64	"	.453125
15 32	"	.468750
31 64	"	.484375
1/2	"	.500000

STANDARD LAP WELDED CHARCOAL IRON BOILER TUBES.

Outside Diameter.	Standard Thickness.	Nearest Birmin'ham Wire Gauge Thickness.	Inside Diameter.	Inside Circumference.	Outside Circumference.	Length of Tube per Sq. Foot, Inside Surface.	Length of Tube per Sq. Foot, Outside Surface.	Inside Area.	Outside Area.	Nomical Weight per Foot.
Inches.	Inches.	Wire Gauge.	Inches.	Inches.	Inches.	Feet.	Feet.	Sq. Inches.	Sq. Inches.	Pounds.
1	.072	15	0.85	2.63	3.14	4.46	3.81	0.57	0.78	.70
1¼	.072	15	1.10	3.47	3.92	3.45	3.05	0.96	1.22	.90
1½	.083	14	1.33	4.19	4.71	2.86	2.54	1.39	1.76	1.24
1¾	.095	13	1.56	4.90	5.49	2.44	2.18	1.91	2.40	1.66
2	.095	13	1.80	5.66	6.28	2.11	1.90	2.55	3.14	1.91
2¼	.095	13	2.05	6.48	7.06	1.85	1.69	3.31	3.97	2.16
2½	.109	12	2.28	7.17	7.85	1.67	1.52	4.09	4.90	2.75
2¾	.109	12	2.53	7.95	8.63	1.50	1.39	5.03	5.94	3.04
3	.109	12	2.78	8.74	9.42	1.37	1.27	6.08	7.06	3.33
3¼	.120	11	3.01	9.46	10.21	1.26	1.17	7.12	8.29	3.96
3½	.120	11	3.26	10.24	10.99	1.17	1.09	8.35	9.62	4.28
3¾	.120	11	3.51	11.03	11.78	1.08	1.01	9.68	11.04	4.60
4	.134	10	3.74	11.75	12.56	1.02	.95	10.99	12.56	5.47
4½	.134	10	4.24	13.32	14.13	.90	.84	14.12	15.90	6.17
5	.148	9	4.72	14.81	15.70	.80	.76	17.49	19.63	7.58
6	.165	8	5.69	17.90	18.84	.67	.63	25.50	28.27	10.16
7	.165	8	6.65	20.91	21.99	.57	.54	34.80	38.48	11.90
8	.165	8	7.63	23.98	25.13	.50	.47	45.79	50.26	13.65
9	.180	7	8.61	27.05	28.27	.44	.42	58.29	63.61	16.76
10	.203	6	9.57	30.07	31.41	.39	.38	71.97	78.54	21.00
11	.220	5	10.56	33.17	34.55	.36	.34	87.47	95.03	25.00
12	.229	4½	11.54	36.26	37.69	.33	.31	103.74	113.09	28.50
13	.238	4	12.52	39.34	40.84	.30	.29	123.18	132.73	32.06
14	.248	3½	13.50	42.41	43.98	.28	.27	143.18	153.93	36.00
15	.259	3	14.48	45.49	47.12	.26	.25	164.71	176.71	40.60
16	.270	2½	15.45	48.56	50.26	.24	.23	187.66	201.06	45.20
17	.284	2	16.43	51.66	53.40	.23	.22	212.22	226.98	49.90
18	.292	1½	17.41	54.71	56.54	.21	.21	238.22	254.46	54.81
19	.300	1	18.40	57.80	59.69	.20	.20	265.90	283.52	59.47
20	.320	0½	19.36	60.82	62.83	.19	.19	294.37	314.15	66.76
21	.340	0	20.32	63.83	65.97	.18	.18	324.31	346.36	73.40

VALUE OF IRON PER TON OF 2240 LBS.

AT FROM 1 TO 3½ CTS. PER LB.

1.	$22.40	1.27½	$28.56	1.55	$34.72	1.82½	$40.88	2.6	$58.24
1.02½	22.96	1.3	29.12	1.57½	35.28	1.85	41.44	2.7	60.48
1.05	23.52	1.32½	29.68	1.6	35.84	1.87½	42.00	2.8	62.72
1.07½	24.08	1.35	30.24	1.62½	36.40	1.9	42.56	2.9	64.96
1.10	24.64	1.37½	30.80	1.65	36.96	1.95	43.68	3.	67.20
1.12½	25.20	1.4	31.36	1.67½	37.52	2.	44.80	3.1	69.44
1.15	25.76	1.42½	31.92	1.7	38.08	2.1	47.04	3.2	71.68
1.17½	26.32	1.45	32.48	1.72½	38.64	2.2	49.28	3.3	73.92
1.20	26.88	1.47½	33.04	1.75	39.20	2.3	51.52	3.4	76.16
1.22½	27.44	1.5	33.60	1.77½	39.76	2.4	53.76	3.5	78.40
1.25	28.00	1.52½	34.16	1.8	40.32	2.5	56.00		

Automatic Pumping Engine, for Domestic and Other Uses.

Both the plumber and steam fitter are frequently called upon to furnish some reliable and simple means of securing a permanent supply of water, and on this account I desire to bring to the notice of the reader, what I consider one of the most perfect machines constructed for such purpose.

The improved pumping engine to which I refer is known in the market as the Bliss-Heath Pump, and is shown in Fig. 284.

Purpose for Which Designed.

The Bliss-Heath Vacuum or atmospheric pumping engine is designed to raise water from street mains, wells, or any other source, to elevated tanks, to furnish a supply of water for the upper stories of city buildings where the pressure is inadequate and for country residences, barns, lawns, etc.

Description of Motor.

The motor is novel and unique, consisting of a double acting vacuum or atmospheric engine, operating a double acting water pump; a low pressure

tubular steel boiler, loaded to 1½ lbs. steam pressure; a surface condenser, and a single acting air pump.

Motive Power of Engine.

The motive power of the engine is the normal atmospheric pressure (14.7 lbs. to the square inch) brought to bear upon the power piston by means of a vacuum formed in the power cylinder, alternately above and below the power piston. The air is expelled from the power cylinder by admitting steam without appreciable pressure, after which the steam itself exhausts into the surface con-

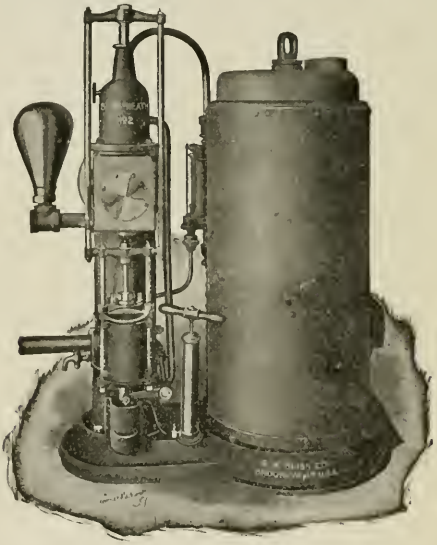


Fig. 284.

denser in which a constant vacuum is maintained. Steam is then automatically admitted to the power cylinder, alternately above and below the power piston, for either the up or the down stroke, breaking the vacuum and giving the piston the required impetus. The principle is the same as that of an ordinary condensing steam engine, except that to operate the Bliss-Heath engine, only enough steam is required to be generated to balance the normal atmospheric pressure. The surface condenser and the air pump perform their usual functions.

Absolutely Safe.

The generator or boiler is exceedingly simple, having at the top a large opening, into which fits a light cover or safety valve, like that of a tea kettle. A very light pressure of steam suffices to lift the cover, affording a vent and making the generator safe from danger of explosion. The boiler is automatically supplied with water by means of a reliable water feeder from the tank pressure.

Skilled Labor Not Required.

No licensed engineer or skilled mechanic is required to operate the engine. Any house servant of ordinary intelligence can operate it with absolute safety and efficiency.

Fuel Required.

Either coal or wood may be used as a fuel for this pumping engine; however, the best results are obtained by using a clear, light, coal fire.

This automatic pump is also intended to be used for deep well work, and in such cases is located over the well. This is the only steam pumping engine to our knowledge at the present time that operates to its full capacity with the low pressure of one pound of steam, and a special advantage in this pump is that when used in buildings having a low pressure steam heating apparatus, the steam from the heating plant can be used for the purpose of operating the pump during the cold season of the year, thus saving in both fuel and labor.

The Bliss-Heath Pumping engine just described is manufactured by the E. W. Bliss Co., Brooklyn, N. Y.

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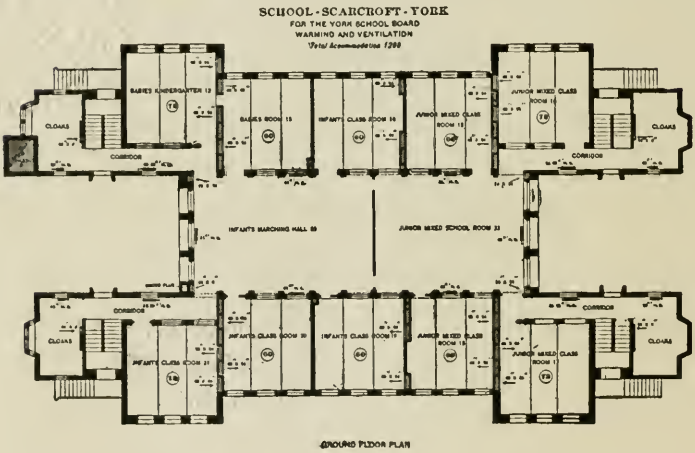

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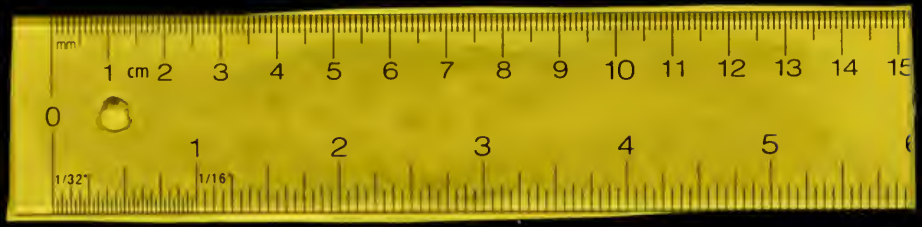
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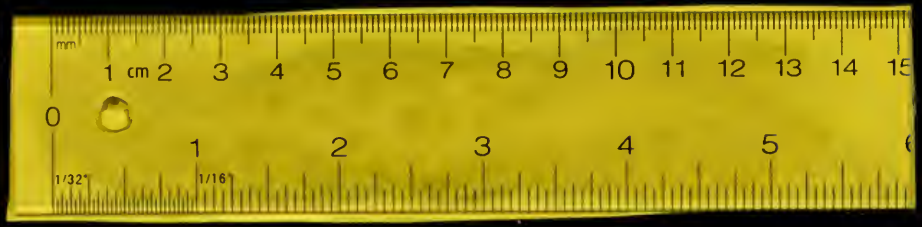
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